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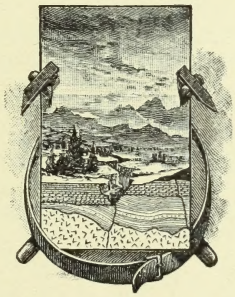
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

# WATER-SUPPLY PAPERS

## Nos. 213-218



WASHINGTON
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Water-supply paper 213; Surface water supply of California, 1906.
same, 214; Surface water supply of north Pacific Coast drainage, 1906.
same, 215; Geology, etc., of part of Mo. R. Valley in northeastern Nebraska.
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same, 217; Water resources of Beaver Valley, Utah.
same, 218; Water-supply investigations in Alaska, 1906–07.

Water-Supply and Irrigation Paper No. 213 Series P, Hydrographic Progress Reports, 67

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

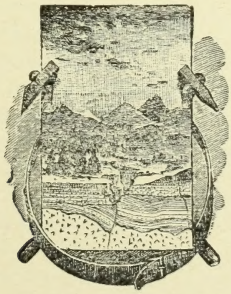
# THE SURFACE WATER SUPPLY OF CALIFORNIA, 1906

## WITH A SECTION ON GROUND WATER LEVELS IN SOUTHERN CALIFORNIA

(GREAT BASIN AND PACIFIC OCEAN DRAINAGES IN CALIFORNIA AND LOWER COLORADO RIVER DRAINAGE)

W. B. CLAPP
DISTRICT HYDROGRAPHER

IN COOPERATION WITH CALIFORNIA STATE BOARD OF EXAMINERS



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# SURFACE WATER SUPPLY OF CALIFORNIA 1906.[a]

W. B. Clapp,
*District Hydrographer.*[b]

## INTRODUCTION.

### SCOPE OF WORK.

The water supply of the United States is of more importance to the life and pursuits of the people than is any other natural resource. In the arid States the limit of agricultural development is determined by the amount of water available for irrigation; while in all parts of the country the increase in the population of cities and towns makes necessary additional water supplies for domestic and industrial uses, in procuring which both the quantity and the quality of the water that may be obtained must be considered. The location of manufacturing plants may depend largely on the water-power facilities and on the character of the water. The notable advances made in the electric transmission of power have led to the utilization of water powers for the operation of manufacturing establishments, railroads, and municipal lighting plants, many of which are at some distance from the places at which the power is developed.

The intelligent establishment and maintenance of enterprises or industries that depend on the use of water demands a thorough knowledge of the flow of the streams and an understanding of the conditions affecting that flow. This knowledge should be based on data showing both the total flow and the distribution of the flow throughout the year, in order that normal fluctuations may be provided for. As the flow of a stream is variable from year to year estimates of future flow can be made only from a study of observations covering several years. The rapid increase in the development

[a] This report contains information similar to that published in previous years under the title "Report on Progress of Stream Measurements."

[b] The data in this report have been collected under the direction of W. B. Clapp, assisted by W. F. Martin, R. S. Hawley, C. H. Lee, and W. C. Sawyer, and have been prepared for publication under the direction of John C. Hoyt, by R. H. Bolster, Robert Follansbee, F. F. Henshaw, J. E. Stewart, and H. D. Padgett.

of the water resources of the United States has caused a great demand by engineers for information in regard to the flow of streams, as it is now generally realized that the failure of many large power, irrigation, and other projects has been due to the fact that the plans were made without sufficient trustworthy information in respect to the water supply.

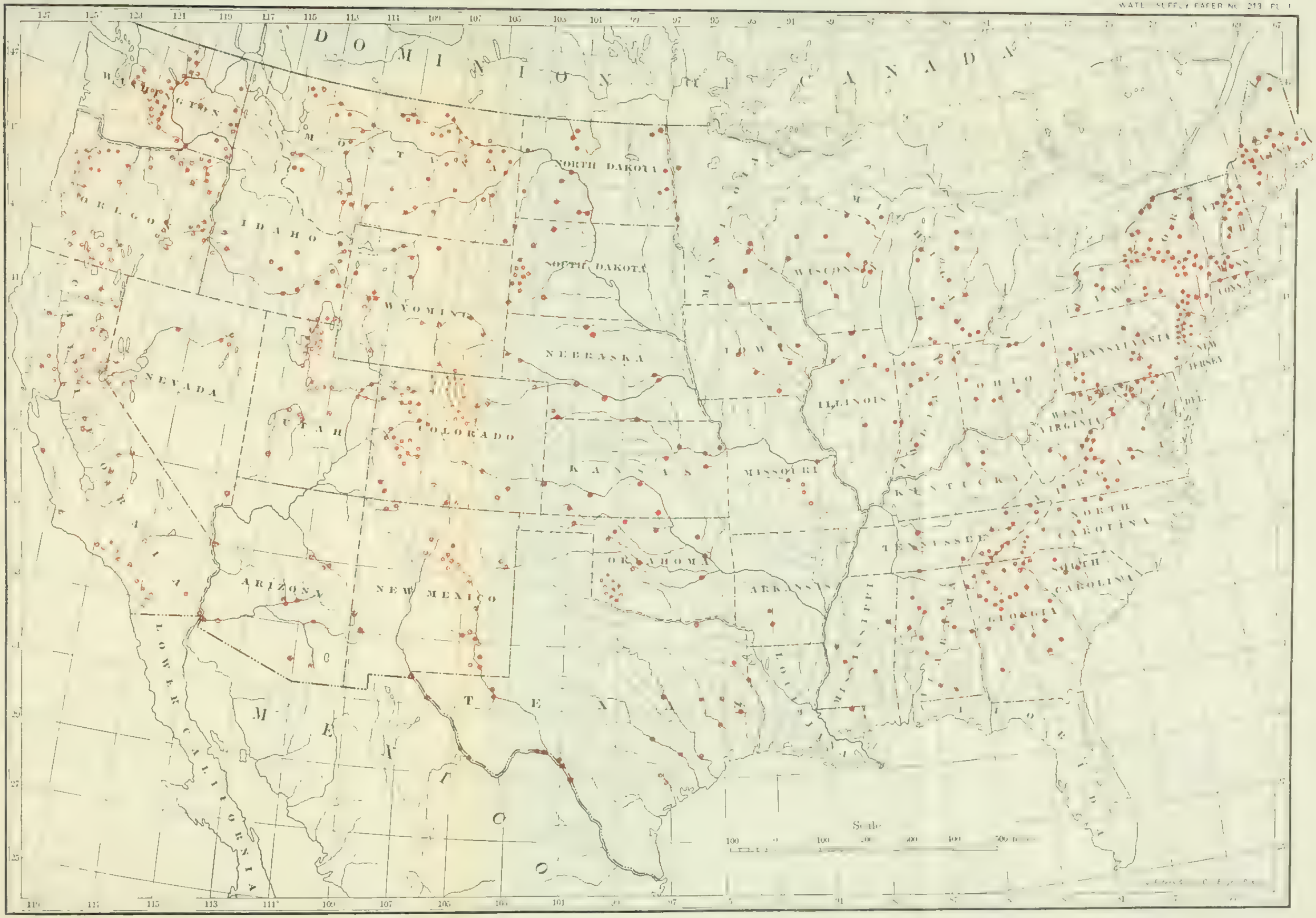
Owing to the broad scope of these hydrographic investigations and the length of time they should cover in order that the records may be of greatest value, it is, in general, impossible for private individuals to collect the necessary data, and as many of the streams traverse more than one State this work does not properly fall within the province of the State authorities. The United States Geological Survey has therefore, by means of specific appropriations by Congress, for several years systematically made records of stream flow, with the view to ultimately determining all the important features governing the flow of the principal streams of the country. In carrying out this plan stations are established on the streams and maintained for a period long enough to show their regimen or general behavior. When a record that is sufficient for this purpose has been obtained for any stream, the work on that stream is discontinued. The order in which the streams are measured is determined by the degree of their importance.

During 1906 the regimen of flow was studied at about 700 stations distributed along the various rivers throughout the United States, as shown on Pl. I. In addition to these records, data in regard to precipitation, evaporation, water power, and river profiles were obtained in many sections of the country.

These data have been assembled by drainage areas and are published in a series of fourteen Water-Supply and Irrigation Papers, Nos. 201 to 214, inclusive, each of which pertains to the surface-water resources of a group of adjacent areas. In these papers are embodied not only the data collected in the field, but also the results of computations based on these data, and other information that has a direct bearing on the subject, such as descriptions of basins and the streams draining them, utility of the water resources, etc. The list follows:

*Water-Supply and Irrigation Papers on Surface Water Supply, 1906.*

201. Surface water supply of New England, 1906. (Atlantic coast of New England drainage.)
202. Surface water supply of the Hudson, Passaic, Raritan, and Delaware river drainages, 1906.
203. Surface water supply of the Middle Atlantic States, 1906. (Susquehanna, Gunpowder, Patapsco, Potomac, James, Roanoke, and Yadkin river drainages.)
204. Surface water supply of the Southern Atlantic and Eastern Gulf States, 1906. (Santee, Savannah, Ogeechee, and Altamaha rivers, and eastern Gulf of Mexico drainages.)




MAP OF UNITED STATES SHOWING LOCATION OF PRINCIPAL RIVER STATIONS MAINTAINED DURING 1906.

205. Surface water supply of the Ohio and lower eastern Mississippi river drainages, 1906.
206. Surface water supply of the Great Lakes and St. Lawrence River drainages, 1906.
207. Surface water supply of the upper Mississippi River and Hudson Bay drainages, 1906.
208. Surface water supply of the Missouri River drainage, 1906.
209. Surface water supply of the lower western Mississippi River drainage, 1906.
210. Surface water supply of the western Gulf of Mexico and Rio Grande drainages, 1906.
211. Surface water supply of the Colorado River drainage above Yuma, 1906.
212. Surface water supply of the Great Basin drainage, 1906.
213. Surface water supply of California, 1906. (The Great Basin and Pacific Ocean drainages in California, and Colorado River drainage below Yuma.)
214. Surface water supply of the North Pacific Coast drainage, 1906.

The records at most of the stations discussed in these reports extend over a series of years. An index of the reports containing such records up to and including 1903 has been published in Water-Supply Paper No. 119. The following table gives, by years and primary drainage basins, the numbers of the papers on surface water supply, published from 1901 to 1906.

*Numbers of Water-Supply Papers containing results of stream measurements, 1901–1906.*[a]

| | 1901. | 1902. | 1903. | 1904. | 1905. | 1906. |
|---|---|---|---|---|---|---|
| | *No.* | *No.* | *No.* | *No.* | *No.* | *No.* |
| Atlantic Coast of New England drainage | 65, 75 | 82 | 97 | 124 | 165 | 201 |
| Hudson, Passaic, Raritan, and Delaware river drainages | 65, 75 | 82 | 97 | 125 | 166 | 202 |
| Susquehanna, Gunpowder, Patapsco, Potomac, James, Roanoke, and Yadkin river drainages | 65, 75 | 82, 83 | 97, 98 | 126 | 167 | 203 |
| Santee, Savannah, Ogeechee, and Altamaha rivers, and eastern Gulf of Mexico drainages | 65, 75 | 83 | 98 | 127 | 168 | 204 |
| Ohio and lower eastern Mississippi river drainages | 65, 75 | 83 | 98 | 128 | 169 | 205 |
| Great Lakes and St. Lawrence River drainages | 65 | 83 | 97 | 129 | 170 | 206 |
| Hudson Bay and upper eastern and western Mississippi River drainages | 65, 66, 75 | 83, 84, 85 | 98, 99, 100 | 128, 130 | 171 | 207 |
| Missouri River drainage | 66, 75 | 84 | 99 | 130, 131 | 172 | 208 |
| Meramec, Arkansas, Red, and lower western Mississippi river drainages | 66, 75 | 84 | 99 | 131 | 173 | 209 |
| Western Gulf of Mexico and Rio Grande drainages | 66, 75 | 84 | 99 | 132 | 174 | 210 |
| Colorado River drainage above Yuma | 66, 75 | 85 | 100 | 133 | 175 | 211 |
| The Great Basin drainage | 66, 75 | 85 | 100 | 133 | 176 | 212 |
| The Great Basin and Pacific Ocean drainages in California, and Colorado River drainage below Yuma | 66, 75 | 85 | 100 | 134 | 177 | 213 |
| North Pacific Coast drainage | 66, 75 | 85 | 100 | 135 | 178 | 214 |

[a] Reports containing data for years prior to 1901 are noted in the series list at the end of this paper.

## DEFINITIONS.

The volume of water flowing in a stream—the "run-off" or "discharge"—is expressed in various terms, each of which has become associated with a certain class of work. These terms may be divided into two groups: (1) Those which represent a rate of flow, as second-feet, gallons per minute, miner's inches, and run-off in second-feet per

square mile, and (2) those which represent the actual quantity of water, as run-off in depth in inches and acre-feet. They may be defined as follows:

"Second-foot" is an abbrevation for cubic foot per second and is the quantity of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second. It is generally used as a fundamental unit from which others are computed.

"Gallons per minute" is generally used in connection with pumping and city water supply.

The "miner's inch" is the quantity of water that passes through an orifice 1 inch square under a head which varies locally. It has been commonly used by miners and irrigators throughout the West and is defined by statute in each State in which it is used.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area.

"Run-off in inches" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

"Acre-foot" is equivalent to 43,560 cubic feet, and is the quantity required to cover an acre to the depth of 1 foot. It is commonly used in connection with storage for irrigation work. There is a convenient relation between the second-foot and the acre-foot: One second-foot flowing for twenty-four hours will deliver 86,400 cubic feet, or approximately 2 acre-feet.

## EXPLANATION AND USE OF TABLES.

For each regular gaging station are given, as far as available, the following data:

1. Description of station.
2. List of discharge measurements.
3. Gage-height table.
4. Rating table.
5. Table of monthly and yearly discharges and run-off.
6. Tables showing discharge and horsepower and the number of days during the year when the same are available.

The descriptions of stations give such general information about the locality and equipment as would enable the reader to find and use the station, and they also give, as far as possible, a complete history of all the changes that have occurred since the establishment of the station that would be factors in using the data collected.

The discharge-measurement table gives the results of the discharge measurements made during the year, including the date, name of the hydrographer, width and area of cross section, gage height, and discharge in second-feet.

The table of daily gage heights gives the daily fluctuations of the surface of the river as found from the mean of the gage readings taken each day. The gage height given in the table represents the elevation of the surface of the water above the zero of the gage. At most stations the gage is read in the morning and in the evening.

The discharge measurements and gage heights are the base data from which the other tables are computed. In cases of extensive development it is expected that engineers will use these original data in making their calculations, as the computations made by the Survey are based on the data available at the time they are made and should be reviewed and, if necessary, revised when additional data are available.

The rating table gives the discharge in second-feet corresponding to various stages of the river as given by the gage heights. It is published to enable engineers to determine the daily discharge in case this information is desired.

In the table of monthly discharge the column headed "Maximum" gives the mean flow for the day when the mean gage height was highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day, there might have been short periods when the water was higher and the corresponding discharge larger than given in this column. Likewise in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow for each second during the month. Upon this the computations for the remaining columns, which are defined on page 10, are based.

The values in the table of monthly discharge are intended to give only a general idea of the conditions of flow at the station, and it is not expected that they will be used for other than preliminary estimates.

In most work where data in regard to flow are used the regimen of flow is of primary importance. Therefore for the principal stations tables have been prepared showing the horsepower that can be developed at various rates of flow, and the length of time that these rates of flow and the corresponding horsepower are available. These tables have been prepared on a basis of 80 per cent efficiency on the turbines, and the horsepower per foot of fall is given in order that the reader can determine the horsepower for any fall.

In the computations, sufficient significant figures have been used so that the percentage of error in the tables will not in general exceed

1 per cent. Therefore, most of the values in the tables are given to only three significant figures. In making the various computations, Thatcher's slide rule, Crelle's tables, and computation machines have been generally used.

In order to give engineers an idea of the relative value of the various data, notes in regard to accuracy are given as far as possible. This accuracy depends on the general local conditions at the gaging stations and the amount of data collected. Every effort possible is made to so locate the stations that the data collected will give a high degree of accuracy. This is not always possible, but it is considered better to publish rough values with explanatory notes rather than no data.

In the accuracy notes the following terms have been used, indicating the probable accuracy, in per cent, of the mean monthly flow. As these values are mean values, the error in the value for the flow of any individual day may be much larger.

Excellent indicates that the mean monthly flow is probably accurate to within 5 per cent; good, to within 10 per cent; fair, to within 15 per cent; approximate, to within 25 per cent.

### CONVENIENT EQUIVALENTS.

Following is a table of convenient equivalents for use in hydraulic computations:

1 second-foot equals 40 California miner's inches (law of March 23, 1901).
1 second-foot equals 38.4 Colorado miner's inches.
1 second-foot equals 40 Arizona miner's inches.
1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,272 gallons for one day.
1 second-foot equals 6.23 British imperial gallons per second.
1 second-foot for one year covers 1 square mile 1.131 feet or 13.572 inches deep.
1 second-foot for one year equals 31,536,000 cubic feet.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot for one day covers 1 square mile 0.03719 inch deep.
1 second-foot for one 28-day month covers 1 square mile 1.041 inches deep.
1 second-foot for one 29-day month covers 1 square mile 1.079 inches deep.
1 second-foot for one 30-day month covers 1 square mile 1.116 inches deep.
1 second-foot for one 31-day month covers 1 square mile 1.153 inches deep.
1 second-foot for one day equals 1.983 acre-feet.
1 second-foot for one 28-day month equals 55.54 acre-feet.
1 second-foot for one 29-day month equals 57.52 acre-feet.
1 second-foot for one 30-day month equals 59.50 acre-feet.
1 second-foot for one 31-day month equals 61.49 acre-feet.
100 California miner's inches equal 18.7 United States gallons per second.
100 California miner's inches equal 96.0 Colorado miner's inches.
100 California miner's inches for one day equal 4.96 acre-feet.
100 Colorado miner's inches equal 2.60 second-feet.
100 Colorado miner's inches equal 19.5 United States gallons per second.
100 Colorado miner's inches equal 104 California miner's inches.
100 Colorado miner's inches for one day equal 5.17 acre-feet.
100 United States gallons per minute equal 0.223 second-foot.

100 United States gallons per minute for one day equal 0.442 acre-foot.
1,000,000 United States gallons per day equal 1.55 second-feet.
1,000,000 United States gallons equal 3.07 acre-feet.
1,000,000 cubic feet equal 22.95 acre-feet.
1 acre-foot equals 325,850 gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-foot per year.
1 foot equals 0.3048 meter.
1 mile equals 1.60935 kilometers.
1 mile equals 5,280 feet.
1 acre equals 0.4047 hectare.
1 acre equals 43,560 square feet.
1 acre equals 209 feet square, nearly.
1 square mile equals 2.59 square kilometers.
1 cubic foot equals 0.0283 cubic meter.
1 cubic foot equals 7.48 gallons.
1 cubic foot of water weighs 62.5 pounds.
1 cubic meter per minute equals 0.5886 second-foot.
1 horsepower equals 550 foot-pounds per second.
1 horsepower equals 76.0 kilogram-meters per second.
1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.80 feet.
1⅓ horsepower equal about 1 kilowatt.

To calculate water power quickly: $\frac{\text{Sec.-ft.} \times \text{fall in feet}}{11}$ = net horsepower on water wheel, realizing 80 per cent of theoretical power.

## FIELD METHODS OF MEASURING STREAM FLOW.

The methods used in collecting these data and in preparing them for publication are given in detail in Water-Supply Papers No. 94 (Hydrographic Manual, U. S. Geological Survey) and No. 95 (Accuracy of Stream Measurements). In order that persons using this report may readily become acquainted with the general methods employed, the following brief descriptions are given:

Streams may be divided, with respect to their physical conditions, into three classes: (1) Those with permanent beds; (2) those with beds which change only during extreme low or high water; (3) those with constantly shifting beds. In determining the daily flow special methods are necessary for each class. The data upon which the determinations are based and the methods of collecting them are, however, in general the same.

There are three distinct methods of determining the flow of open-channel streams: (1) By measurements of slope and cross section and the use of Chezy's and Kutter's formulas; (2) by means of a weir; (3) by measurements of the velocity of the current and of the area of the cross section. The method chosen for any case depends upon the local physical conditions, the degree of accuracy desired, the funds available, and the length of time that the record is to be continued.

*Slope method.*—Much information has been collected relative to the coefficients to be used in the Chezy formula, $v=c\sqrt{R\,s}$. This has been utilized by Kutter, both in developing his formula for $c$ and in determining the values of the coefficient $n$ which appears therein. The results obtained by the slope method are in general only roughly approximate, owing to the difficulty in obtaining accurate data and the uncertainty of the value for $n$ to be used in Kutter's formula. The most common use of this method is in estimating the flood discharge of a stream when the only data available are the cross section, the slope as shown by marks along the bank, and a knowledge of the general conditions.

*Weir method.* When funds are available and the conditions are such that sharp-crested weirs can be erected, these offer the best facilities for determining flow. If dams are suitably situated and constructed, they may be utilized for obtaining reliable measurements of flow. The conditions necessary to insure good results may be divided into two classes: (1) Those relating to the physical characteristics of the dam itself and (2) those relating to the diversion and use of water around and through the dam.

The physical requirements are as follows: (*a*) Sufficient height of dam, so that backwater will not interfere with free fall over it; (*b*) absence of leaks of appreciable magnitude; (*c*) topography or abutments which confine the flow over the dam at high stages; (*d*) level crests which are kept free from obstructions caused by floating logs or ice; (*e*) crests of a type for which the coefficients to be used in $Q=c\,b\,h^{\frac{3}{2}}$, or some similar standard weir formula, are known (see Water-Supply Papers Nos. 180 and 200[a]); (*f*) either no flash boards or exceptional care in reducing leakage through them and in recording their condition.

Preferably, there should be no diversion of water through or around the dam. Generally, however, a dam is built for purposes of power or navigation, and part or all of the water flowing past it is diverted for such uses. This water is measured and added to that passing over the dam. To insure accuracy in such determinations of flow the amount of water diverted should be reasonably constant. Furthermore, it should be so diverted that it can be measured either by a weir, a current meter, or a simple system of water wheels which are of standard make, or which have been rated as meters under working conditions and so installed that the gate openings, the heads under which they work, and their angular velocities may be accurately observed.

The combination of physical conditions and uses of the water should be such that the determinations of flow will not involve, for a critical stage of considerable duration, the use of a head on a broad-

[a] Water-Supply Paper No. 200 replaces No. 150, the edition of which has been exhausted.

crested dam of less than 6 inches. Moreover, when all other conditions are good, the cooperation of the owners or operators of the plant is still essential if reliable results are to be obtained.

A gaging station at a weir or dam has the general advantage of continuity of record through the period of ice and floods, and the disadvantages of uncertainty of coefficient to be used in the weir formula and of complications in the diversion and use of the water.

*Velocity method.*—The determination of the quantity of water flowing past a certain section of a stream at a given time is termed a discharge measurement. This quantity is the product of two factors—the mean velocity and the area of the cross section. The mean velocity is a function of surface slope, wetted perimeter, roughness of bed, and the channel conditions at, above, and below the gaging section. The area depends upon the contour of the bed and the fluctuations of the water surface. The two principal ways of measuring the velocity of a stream are by floats and current meters.

Great care is taken in the selection and equipment of gaging stations for determining discharge by velocity measurements in order that the data may have the required degree of accuracy. Their essential requirements are practically the same, whether the velocity is determined by meters or floats. They are located, as far as possible, where the channel is straight both above and below the gaging section; where there are no cross currents, backwater, or boils; where the bed of the stream is reasonably free from large projections of a permanent character, and where the banks are high and subject to overflow only at flood stages. The station must be so far removed from the effects of tributary streams and of dams or other artificial obstructions that the gage height shall be an index of the discharge.

Certain permanent or semipermanent structures, usually referred to as "equipment," are generally pertinent to a gaging station. These are a gage for determining the fluctuations of the water surface, bench marks to which the datum of the gage is referred, permanent marks on a bridge or a tagged line indicating the points of measurement, and, where the current is swift, some appliance (generally a secondary cable) to hold the meter in position in the water. As a rule, the stations are located at bridges if the channel conditions are satisfactory, as from them the observations can more readily be made and the cost of the equipment is small.

The floats in common use are the surface, subsurface, and tube or rod floats. A corked bottle with a flag in the top and weighted at the bottom makes one of the most satisfactory surface floats, as it is affected but little by wind. In case of flood measurements, good results can be obtained by observing the velocity of floating cakes of ice or débris. In case of all surface-float measurements coefficients must be used to reduce the observed velocity to the mean

velocity. The subsurface and tube or rod floats are intended to give directly the mean velocity in the vertical. Tubes give excellent results when the channel conditions are good, as in canals.

In measuring velocity by a float, observation is made of the time taken by the float to pass over the "run," a selected stretch of river from 50 to 200 feet long. In each discharge measurement a large number of velocity determinations are made at different points across the stream, and from these observations the mean velocity for the whole section is determined. This may be done by plotting the mean positions of the floats as indicated by the distances from the bank as ordinates and the corresponding times as abscissas. A curve through these points shows the mean time of run at any point across the stream, and the mean time for the whole stream is obtained by dividing the area bounded by this curve and its axis by the width. The length of the run divided by the mean time gives the mean velocity.

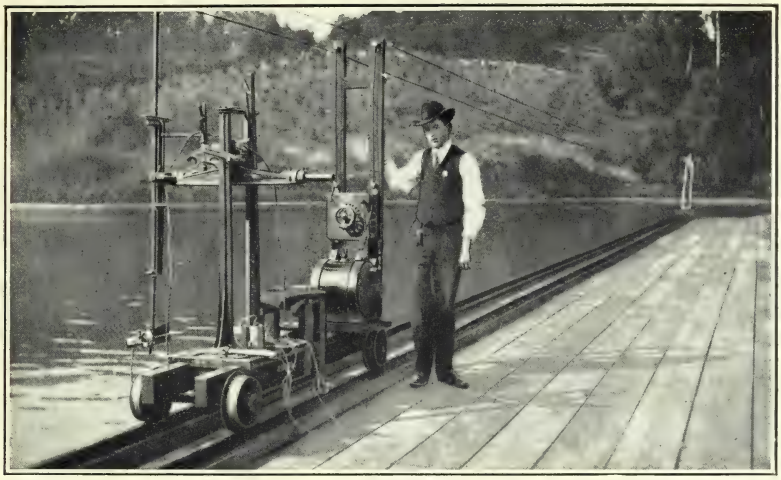
The area used in float measurements is the mean of the areas at the two ends of the run and at several intermediate sections.

The essential parts of the current meters in use are a wheel of some type, so constructed that the impact of flowing water causes it to revolve, and a device for recording or indicating the number of revolutions. The relation between the velocity of the moving water and the revolutions of the wheel is determined for each meter. This rating is done by drawing the meter through still water for a given distance at different speeds, and noting the number of revolutions for each run. From these data a rating table is prepared which gives the velocity per second for any number of revolutions.

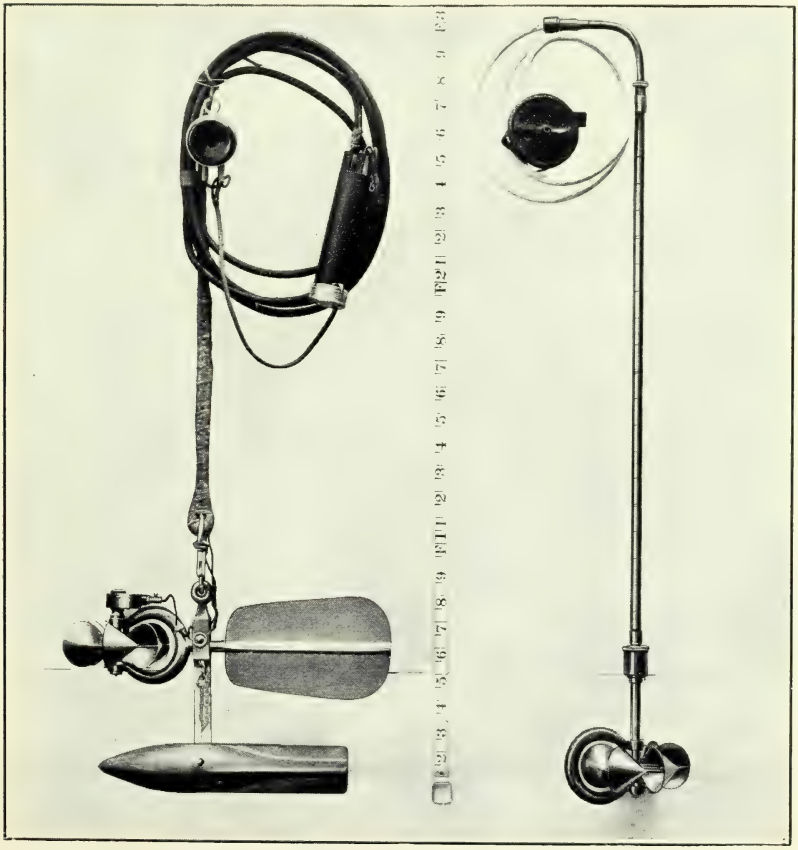
Many kinds of current meters have been constructed. They may, however, be classed in two general types—those in which the wheel is made up of a series of cups, as the Price, and those having a screw-propeller wheel, as the Haskell. Each meter has been developed for use under some special condition. In the case of the small Price meter, shown in Pl. II, *B*, which has been largely developed and extensively used by the United States Geological Survey, an attempt has been made to get an instrument which could be used under practically all conditions.

Current-meter measurements may be made from a bridge, cable, boat, or by wading, and gaging stations may be classified in accordance with such use. Fig. 1 shows a typical cable station.

In making the measurement an arbitrary number of points are laid off on a line perpendicular to the thread of the stream. The points at which the velocity and depth are observed are known as measuring points and are usually fixed at regular intervals, varying from 2 to 20 feet, depending on the size and condition of the stream. Perpendiculars dropped from the measuring points divide the gaging



*A*. CURRENT-METER RATING STATION, LOS ANGELES, CAL.



*B*. PRICE CURRENT METERS.

section into strips. For each strip or pair of strips the mean velocity, area, and discharge are determined independently, so that conditions existing in one part of the stream may not be extended to parts where they do not apply.

Three classes of methods of measuring velocity with current meters are in general use—multiple-point, single-point, and integration.

The three principal multiple-point methods in general use are the vertical velocity-curve; 0.2 and 0.8 depth; and top, bottom, and mid-depth.

In the vertical velocity-curve method a series of velocity determinations are made in each vertical at regular intervals, usually from 0.5 to 1 foot apart. By plotting these velocities as abscissas and their depths as ordinates, and drawing a smooth curve among the resulting points, the vertical velocity-curve is developed. This curve shows graphically the magnitude and changes in velocity from the surface to the bottom of the stream. The mean velocity in the ver-

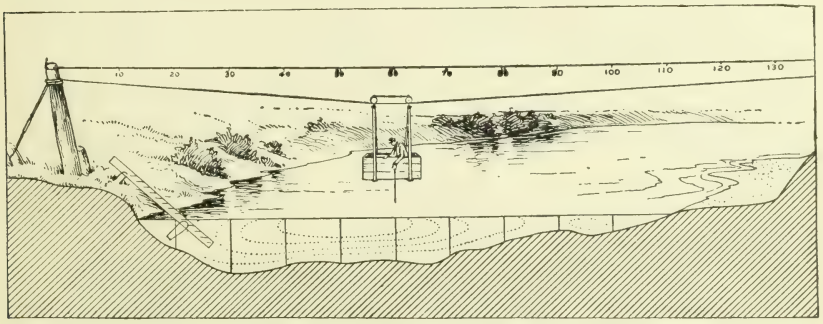


FIG. 1.—Cable station, showing section of river, car, gage, etc.

tical is then obtained by dividing the area bounded by this velocity curve and its axis by the depth. On account of the length of time required to make a complete measurement by this method, its use is limited to the determination of coefficients for purposes of comparison and to measurements under ice.

In the second multiple-point method the meter is held successively at 0.2 and 0.8 of the depth, and the mean of the velocities at these two points is taken as the mean velocity for that vertical. On the assumption that the vertical velocity-curve is a common parabola with horizontal axis, the mean of the velocities at 0.22 and 0.79 of the depth will give (closely) the mean velocity in the vertical. Actual observations under a wide range of conditions show that this second multiple-point method gives the mean velocity very closely for open-water conditions, and, moreover, the indications are that it holds nearly as well for ice-covered rivers.

In the third multiple-point method the meter is held at mid depth,

at 0.5 foot below the surface, and at 0.5 foot above the bottom, and the mean velocity is determined by dividing by 6 the sum of the top velocity, four times the mid-depth velocity, and the bottom velocity. This method may be modified by observing at 0.2, 0.6, and 0.8 depth.

The single-point method consists in holding the meter either at the depth of the thread of mean velocity, or at an arbitrary depth for which the coefficient for reducing to mean velocity has been determined.

Extensive experiments by vertical velocity-curves show that the thread of mean velocity generally occurs at from 0.5 to 0.7 of the total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, at which point the meter is held in the majority of measurements. A large number of vertical velocity-curve measurements, taken on many streams and under varying conditions, show that the average coefficient for reducing the velocity obtained at 0.6 depth to mean velocity is practically unity.

In the other principal single-point method the meter is held near the surface, usually 1 foot below, or low enough to be out of the effect of wind or other disturbing influences. This is known as the subsurface method. The coefficient for reducing the velocity taken at the subsurface to the mean has been found to be from 0.85 to 0.95, depending on the stage, velocity, and channel conditions. The higher the stage the larger the coefficient. This method is especially adapted for flood measurements or when the velocity is so great that the meter can not be kept at 0.6 depth.

The vertical integration method consists in moving the meter at a slow, uniform speed from the surface to the bottom and back again to the surface, and noting the number of revolutions and the time taken in the operation. This method has the advantage that the velocity at each point of the vertical is measured twice. It is useful as a check on the point methods.

The area, which is the other factor in the velocity method of determining the discharge of a stream, depends on the stage of the river, which is observed on the gage, and on the general contour of the bed of the stream, which is determined by soundings. The soundings are usually taken at each measuring point at the time of the discharge measurement, either by using the meter and cable, or by a special sounding line or rod. For streams with permanent beds standard cross sections are usually taken during low water. These sections serve to check the soundings which are taken at the time of the measurements, and from them any change which may have taken place in the bed of the stream can be detected. They are also of value in obtaining the area for use in computations of high-water measurements, as accurate soundings are hard to obtain at high stages.

In computing the discharge measurements from the observed velocities and depths at various points of measurement the measuring section is divided into elementary strips, as shown in fig. 1, and the mean velocity, area, and discharge are determined separately for either a single or a double strip. The total discharge and the area are the sums of those for the various strips, and the mean velocity is obtained by dividing the total discharge by the total area.

The determination of the flow of an ice-covered stream is difficult, owing to diversity and instability of conditions during the winter period and also to the lack of definite information in regard to the laws of flow of water under ice. The method now employed is to make frequent discharge measurements during the frozen periods by the 0.2 and 0.8, and vertical velocity-curve methods, and to keep an accurate record of the conditions, such as the gage height to the surface of the water as it rises in a hole cut in the ice, the thickness and character of the ice, etc.

From these data an approximate estimate of the daily flow can be made by constructing a rating curve (really a series of curves) similar to that used for open channels, but considering, in addition to gage heights and discharge, the varying thickness of ice.

For information in regard to flow under ice cover see Water-Supply Paper No. 187.

### OFFICE METHODS OF COMPUTING RUN-OFF.

There are two principal methods of determining run-off, depending on whether or not the bed of the stream is permanent.

For stations on streams with permanent beds the first step in computing the run-off is the construction of the rating table, which shows the discharge corresponding to any stage of the stream. This rating table is applied to the record of stage to determine the amount of water flowing. The construction of the rating table depends on the method used in measuring flow.

For a station at a weir or dam the basis for the rating table is some standard weir formula. The coefficients to be used in its application depend on the type of dam and other conditions near its crest. After inserting in the weir formula the measured length of crest and assumed coefficient, the discharge is computed for various heads and the rating table constructed.

The data necessary for the construction of a rating table for a velocity-area station are the results of the discharge measurements, which include the record of stage of the river at the time of measurement, the area of the cross section, the mean velocity of the current, and the quantity of water flowing. A thorough knowledge of the conditions at and in the vicinity of the station is also necessary.

The construction of the rating table depends on the following laws of flow for open, permanent channels: (1) The discharge will remain constant so long as the conditions at or near the gaging station remain constant; (2) the discharge will be the same whenever the stream is at a given stage if the change of slope due to the rise and fall of the stream be neglected; (3) the discharge is a function of and increases gradually with the stage.

The plotting of the results of the various discharge measurements, using gage heights as ordinates, and discharge, mean velocity, and area as abscissas, will define curves which show the discharge, mean velocity, and area corresponding to any gage height. For the development of these curves there should be, therefore, a sufficient number of discharge measurements to cover the range of the stage of the stream. Fig. 2 shows a typical rating curve, with its corresponding mean-velocity and area curves.

As the discharge is the product of two factors, the area and the mean velocity, any change in either factor will produce a corresponding change in the discharge. Their curves are therefore constructed in order to study each independently of the other.

The area curve can be definitely determined from accurate soundings extending to the limits of high water. It is always concave toward the horizontal axis or on a straight line, unless the banks of the stream are overhanging.

The form of the mean-velocity curve depends chiefly upon the surface slope, the roughness of the bed, and the cross section of the stream. Of these the slope is the principal factor. In accordance with the relative change of these factors the curve may be either a straight line, convex or concave toward either axis, or a combination of the three. From a careful study of the conditions at any gaging station the form which the vertical velocity-curve will take can be predicted, and it may be extended with reasonable certainty to stages beyond the limits of actual measurements. Its principal use is in connection with the area curve in locating errors in discharge measurements and in constructing the rating table.

The discharge curve is defined primarily by the measurements of discharge, which are studied and weighted in accordance with the local conditions existing at the time of each measurement. The curve may, however, best be located between and beyond the measurements by means of curves of area and mean velocity. This curve under normal conditions is concave toward the horizontal axis and is generally parabolic in form.

In the preparation of the rating table the discharge for each tenth or half tenth on the gage is taken from the curve. The differences between successive discharges are then taken and adjusted according to the law that they shall either be constant or increasing.

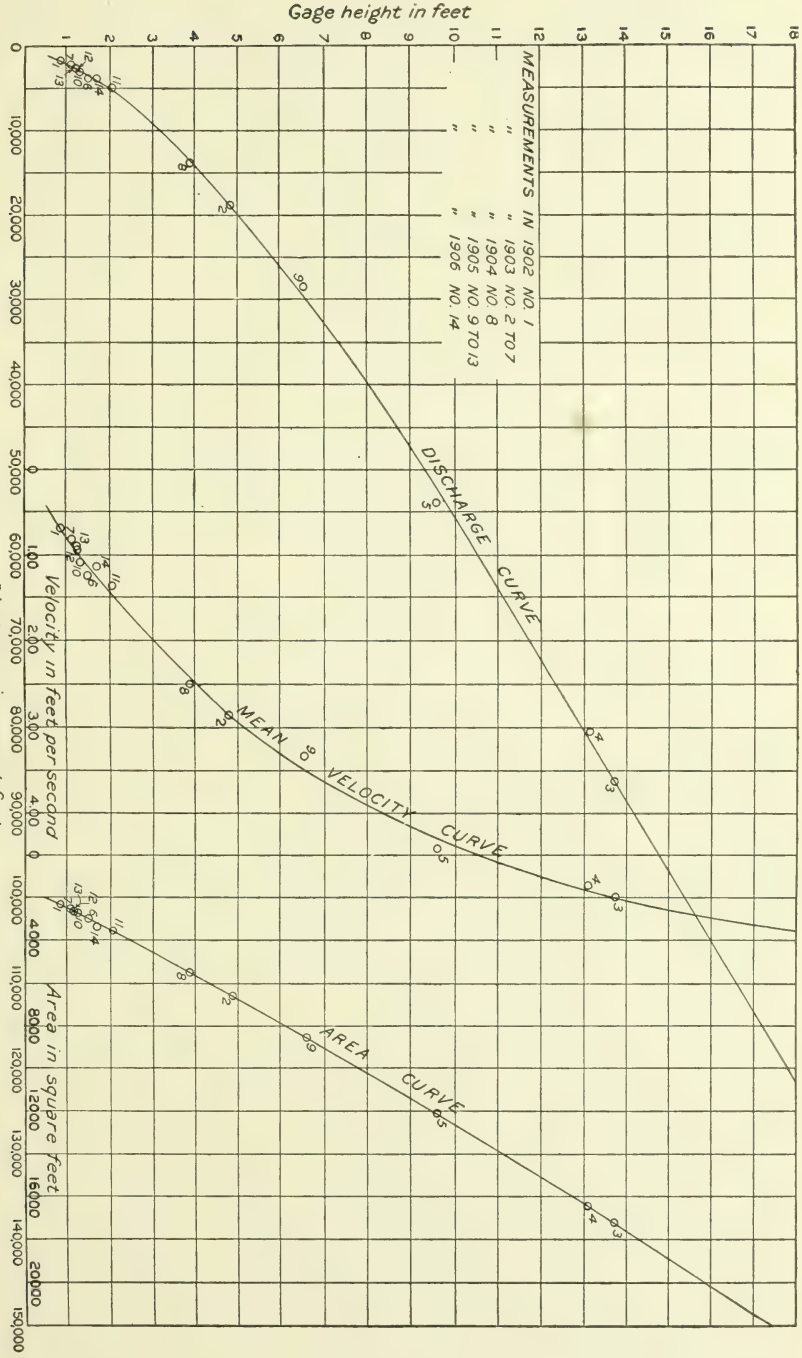

Gage height in feet
MEASUREMENTS IN 1902 NO. 1
" " 1903 NO. 2 TO 7
" " 1904 NO. 8
" " 1905 NO. 9 TO 13
" " 1906 NO. 14
DISCHARGE CURVE
MEAN & VELOCITY CURVE
AREA CURVE
Velocity in feet per second
Area in square feet
Discharge in second-feet

FIG. 2.—Discharge, area, and mean-velocity curves of Potomac River at Point of Rocks, Md.

The determination of daily discharge of streams with changeable beds is a difficult problem. In case there is a weir or dam available, a condition which seldom exists on streams of this class, the discharge can be determined by its use. In case of velocity-area stations frequent discharge measurements must be made if the determinations of flow are to be other than rough approximations. For stations with beds which shift slowly, or are materially changed only during floods, rating tables can be prepared for periods between such changes and satisfactory results obtained with a limited number of measurements, provided that some of them are taken soon after the change occurs. For streams with continually shifting beds, such as the Colorado and Rio Grande, discharge measurements should be made every two or three days and the discharges for intervening days obtained either by interpolation modified by gage height or by Professor Stout's method, which has been described in full in the Nineteenth Annual Report United States Geological Survey, Part IV, page 323, and in the Engineering News of April 21, 1904. This method, or a graphical application of it, is also much used in determining the flow at stations where the bed shifts but slowly.

## COÖPERATION AND ACKNOWLEDGMENTS.

The hydrographic work of the United States Geological Survey in California is being carried on in cooperation with the State in accordance with acts of the State legislature approved March 16, 1903, and March 20, 1905.

The act of March 16, 1903, which covered the period from July 1, 1903, to June 30, 1905, is in substance as follows:

> The State board of examiners are hereby empowered to enter into contracts with the Director of the United States Geological Survey for the purpose of making topographic maps to the extent of twenty thousand dollars; also for the purpose of gaging streams, surveying reservoir sites and canal locations, for the conservation and utilization of the flood or storm waters of the State, to the extent of fifteen thousand dollars [etc.].

The act of March 20, 1905, is in substance the same as previous act, the appropriations being increased to $30,000 for topography and $20,000 for hydrography, and covering the two fiscal years July 1, 1905, to June 30, 1907.

Assistance has been rendered or records furnished by the following, to whom acknowledgment is due: California State board of examiners, composed of the following members: George C. Pardee, governor; C. F. Curry, secretary of state; U. S. Webb, attorney-general. Acknowledgment is also due to Mr. Lovelace, of Lemoore, Cal., for gage readings on Tulare Lake; to the Kern County Land Company, through A. K. Warren, engineer in charge of water measurements, for the record of Kern River; to the city of Santa Barbara

for cooperation in gaging Santa Ynez River; to the Bay Cities Water Company, through Edwin Duryea, jr., chief engineer, for precipitation and run-off data; to the Great Western Power Company, through Mr. M. A. Viele, chief engineer, for gage heights and stream measurements on Feather River and tributaries and for rainfall and evaporation records near Prattville, Cal.; to the Southern Pacific Company, through its chief engineer, William Hood, for river-stage records of San Joaquin River at Herndon, Cal., and for transportation furnished; and to the officials of the Santa Fe Railway for transportation furnished.

## LOWER COLORADO RIVER DRAINAGE BASIN.[a]

### COLORADO RIVER AT HARDYVILLE, ARIZ.

This station was established May 11, 1905. It is located one-fourth mile above the deserted town of Hardyville, and 7 miles above Fort Mohave, Ariz. The conditions at this station and the bench marks are described in Water-Supply Paper No. 175, page 128.

*Discharge measurements of Colorado River at Hardyville, Ariz., in 1905–6.*

| Date. | Hydrographer. | Gage height. | Discharge. | Date. | Hydrographer. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sec.-ft.* | 1906. | | *Feet.* | *Sec.-ft.* |
| May 17 | O. W. Peterson | 6.65 | 33,140 | April 8 | C. W. Jenkins | 6.90 | 21,500 |
| May 20 | do | 6.95 | 33,910 | April 15 | do | 7.30 | 24,100 |
| May 27 | C. W. Jenkins | 11.20 | 69,010 | April 22 | do | 8.10 | 32,200 |
| June 4 | do | 10.50 | 64,750 | April 24 | Murphy and Lee | 8.84 | 37,500 |
| June 10 | do | 14.50 | 107,700 | May 3 | Lee and Jenkins | 9.00 | 40,800 |
| June 18 | do | 12.80 | 81,030 | May 6 | C. W. Jenkins | 8.70 | 33,100 |
| June 25 | do | 10.15 | 52,860 | May 13 | do | 11.20 | 67,200 |
| July 9 | do | 6.70 | 30,650 | May 20 | C. H. Lee | 11.90 | 63,700 |
| July 16 | do | 5.70 | 22,400 | May 27 | C. W. Jenkins | 14.00 | 92,800 |
| July 23 | do | 5.10 | 17,620 | June 3 | do | 14.05 | 96,200 |
| July 30 | do | 4.00 | 14,580 | June 9 | do | 13.10 | 92,000 |
| August 6 | do | 5.00 | 17,040 | June 16 | do | 14.70 | 109,000 |
| August 13 | do | 4.20 | 12,270 | July 1 | F. T. Cavin | 10.35 | 63,700 |
| August 27 | do | 4.00 | 11,650 | July 8 | Lee and Cavin | 19.30 | 47,500 |
| September 2 | do | 3.20 | 5,934 | July 15 | F. T. Cavin | 8.50 | 34,000 |
| September 17 | do | 3.40 | 7,523 | July 22 | do | 8.56 | 38,100 |
| October 1 | do | 3.00 | 4,657 | July 29 | do | 7.55 | 27,600 |
| October 15 | do | 3.90 | 6,579 | August 5 | do | 7.35 | 24,400 |
| October 29 | do | 3.60 | 6,574 | August 11 | do | 7.00 | 19,500 |
| November 4 | Jenkins and Lee | 3.48 | 5,949 | August 18 | do | 6.45 | 16,200 |
| November 12 | C. W. Jenkins | 3.85 | 6,504 | August 25 | do | 6.20 | 14,200 |
| November 19 | do | 3.70 | 5,979 | September 1 | do | 6.50 | 15,500 |
| November 25 | do | 3.60 | 5,757 | September 8 | do | 6.63 | 12,700 |
| December 3 | do | 6.00 | 17,850 | September 15 | do | 6.50 | 11,400 |
| | | | | September 22 | C. J. Brunk | 6.73 | 12,100 |
| 1906. | | | | September 29 | do | 7.38 | 16,900 |
| January 1 | C. W. Jenkins | 3.70 | 3,430 | October 6 | do | 7.63 | 16,000 |
| January 7 | do | 3.50 | 3,440 | October 13 | do | 7.00 | 12,000 |
| January 14 | do | 3.30 | 3,360 | October 20 | do | 6.75 | 9,840 |
| January 21 | do | 4.15 | 5,900 | October 28 | do | 6.60 | 8,400 |
| January 28 | do | 4.50 | 7,850 | November 4 | do | 6.80 | 9,470 |
| February 5 | do | 4.10 | 5,110 | November 10 | do | 7.30 | 12,800 |
| February 12 | do | 4.40 | 6,390 | November 17 | do | 7.15 | 10,300 |
| February 25 | do | 4.30 | 6,350 | November 24 | do | 6.85 | 9,430 |
| March 4 | do | 4.10 | 5,710 | December 1 | do | 6.70 | 7,720 |
| March 11 | do | 4.20 | 1,520 | December 8 | do | 8.48 | 23,300 |
| March 18 | do | 6.40 | 19,400 | December 15 | do | 7.25 | 11,300 |
| March 25 | do | 5.80 | 12,800 | December 22 | do | 6.89 | 9,230 |
| April 1 | do | 7.50 | 30,000 | December 29 | do | 6.50 | 7,160 |

[a] A description of the general features of Colorado River drainage will be found in Water-Supply Paper No. 211.

*Daily gage height, in feet, of Colorado River at Hardyville, Ariz., for 1905–6.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905. | | | | | | | | | | | | |
| 1 | | | | | | a11.8 | 8.55 | 4.5 | 3.4 | 3.75 | 3.45 | 7.4 |
| 2 | | | | | | a11.5 | 8.4 | 4.5 | 3.4 | 4.05 | 3.45 | 7.1 |
| 3 | | | | | | a11.1 | 8.3 | a4.65 | 3.2 | 4.7 | 3.5 | 6.05 |
| 4 | | | | | | 10.7 | 8.0 | 4.8 | 3.2 | 4.35 | 3.45 | 5.25 |
| 5 | | | | | | 10.8 | 7.9 | 5.2 | 3.45 | 5.1 | 3.5 | 4.8 |
| 6 | | | | | | 11.85 | 7.55 | 5.0 | 3.55 | 4.8 | 3.5 | 4.5 |
| 7 | | | | | | 12.5 | 7.3 | 4.7 | 3.5 | 4.8 | 3.6 | 4.3 |
| 8 | | | | | | 13.1 | 7.0 | 4.7 | 3.6 | 4.7 | 4.0 | a4.2 |
| 9 | | | | | | 13.7 | 6.7 | 4.85 | 3.5 | 4.7 | 3.85 | 4.1 |
| 10 | | | | | | 14.4 | 6.7 | 4.6 | 3.6 | 4.45 | 3.85 | 3.9 |
| 11 | | | | | 6.85 | 14.3 | 6.5 | 4.5 | 4.0 | 4.25 | 3.75 | 3.75 |
| 12 | | | | | 6.9 | 14.0 | 6.15 | 4.3 | 3.7 | 4.1 | 3.85 | 3.75 |
| 13 | | | | | 6.95 | 14.3 | a6.0 | 4.25 | 3.5 | a4.0 | 3.8 | 3.8 |
| 14 | | | | | 7.15 | 14.45 | 5.85 | a4.15 | 3.5 | 3.95 | 3.65 | 3.8 |
| 15 | | | | | 7.15 | 14.5 | 5.2 | 4.0 | 3.45 | 3.85 | 3.85 | 3.7 |
| 16 | | | | | 6.95 | 13.8 | 5.85 | 4.0 | 3.45 | 3.8 | 3.75 | 3.7 |
| 17 | | | | | 6.7 | 13.3 | 5.5 | 3.9 | 3.4 | 3.7 | 3.7 | 3.7 |
| 18 | | | | | 6.8 | 12.8 | 5.3 | 3.8 | 3.3 | 3.7 | 3.7 | 3.7 |
| 19 | | | | | 6.95 | 12.5 | 5.25 | 3.8 | 3.2 | 3.7 | 3.7 | 3.6 |
| 20 | | | | | 7.0 | 12.2 | a5.2 | 3.8 | 3.2 | 3.6 | 3.7 | 3.6 |
| 21 | | | | | 7.35 | 11.85 | 5.1 | 3.75 | 3.05 | 3.55 | 3.6 | a3.65 |
| 22 | | | | | 8.1 | 11.35 | 5.1 | 3.75 | 3.05 | 3.5 | 3.6 | 3.7 |
| 23 | | | | | 8.8 | 10.8 | 5.1 | 3.6 | 3.0 | 3.5 | 3.6 | 3.8 |
| 24 | | | | | 9.5 | 10.5 | 4.95 | 3.6 | 3.05 | a3.5 | 3.7 | 3.8 |
| 25 | | | | | 9.9 | 10.15 | 4.85 | 3.6 | 2.95 | 3.45 | 3.6 | 3.8 |
| 26 | | | | | 10.6 | 10.0 | 4.7 | 4.75 | 2.95 | 3.5 | 5.4 | 3.95 |
| 27 | | | | | 11.1 | 9.5 | 4.7 | 3.7 | 2.95 | 3.45 | 5.4 | 3.9 |
| 28 | | | | | 11.5 | 9.1 | 4.7 | 3.4 | 2.95 | 3.5 | 5.1 | 3.9 |
| 29 | | | | | 12.7 | 9.2 | 4.7 | 3.3 | 3.95 | 3.55 | 5.0 | 3.9 |
| 30 | | | | | a12.4 | 9.6 | 4.65 | 3.4 | 3.95 | 3.5 | 5.1 | 3.8 |
| 31 | | | | | a12.1 | ..... | 4.6 | 3.4 | ..... | 3.5 | ..... | a3.8 |
| 1906. | | | | | | | | | | | | |
| 1 | a3.7 | a4.2 | 4.4 | 7.85 | 9.5 | 13.2 | 10.25 | 7.4 | 6.5 | a7.55 | 6.65 | 6.7 |
| 2 | 3.5 | 4.1 | 4.2 | 8.25 | 9.2 | 13.8 | 10.0 | 7.4 | 6.35 | 7.5 | 6.6 | 6.65 |
| 3 | 3.5 | 4.05 | 4.2 | 7.9 | 9.1 | 14.0 | a9.7 | 7.6 | 6.35 | 7.7 | a6.7 | 6.7 |
| 4 | 3.4 | 4.1 | 4.1 | 7.4 | 9.2 | 13.8 | 9.4 | 7.5 | 6.5 | 7.7 | 6.8 | 6.65 |
| 5 | 3.35 | 4.1 | 4.1 | 7.45 | 8.9 | 13.75 | 9.4 | 7.35 | 6.5 | 7.7 | 6.75 | 6.6 |
| 6 | 3.4 | 4.1 | 4.1 | 7.1 | 8.8 | 13.8 | 9.2 | 7.2 | 6.55 | 7.6 | a6.8 | 6.8 |
| 7 | 3.5 | 4.2 | 4.1 | 6.85 | 8.7 | 13.6 | 9.35 | 7.0 | 6.55 | 7.4 | 6.9 | 7.45 |
| 8 | 3.35 | 4.2 | 4.2 | 6.9 | 8.1 | 13.3 | 9.25 | 7.1 | 6.7 | 7.3 | 6.9 | 8.45 |
| 9 | 3.3 | 4.3 | 4.2 | 6.9 | 8.7 | 13.0 | 9.35 | 7.0 | 6.7 | 7.2 | 7.0 | 7.9 |
| 10 | 3.45 | 4.4 | 4.2 | 6.9 | 9.3 | 13.1 | 9.1 | 7.0 | 6.7 | 7.1 | 7.3 | 7.7 |
| 11 | 3.3 | a4.4 | 4.25 | 7.1 | 10.1 | 13.25 | 8.9 | 7.05 | 6.55 | 7.1 | 7.3 | a7.6 |
| 12 | 3.35 | 4.4 | 4.2 | 7.1 | 10.5 | 13.5 | 8.8 | 6.85 | 6.6 | 7.1 | a7.3 | 7.5 |
| 13 | 3.3 | 4.4 | 4.35 | 7.6 | 11.05 | 13.1 | 8.8 | 6.8 | 6.55 | 7.0 | 7.3 | 7.4 |
| 14 | 3.4 | 4.4 | 4.5 | 7.5 | 11.85 | 13.95 | 8.45 | 6.7 | 6.55 | 7.0 | 7.2 | 7.3 |
| 15 | 3.35 | 4.3 | 5.1 | 7.35 | 11.9 | a14.0 | 8.5 | 6.65 | 6.55 | 6.95 | 7.15 | 7.25 |
| 16 | 3.4 | 4.3 | a5.8 | 7.4 | 12.5 | 14.1 | 8.35 | 6.6 | 6.55 | 6.9 | 7.15 | 7.1 |
| 17 | 3.7 | 4.3 | 6.4 | 7.45 | 12.75 | 14.6 | 8.55 | 6.55 | 6.5 | 6.85 | 7.15 | 6.95 |
| 18 | 3.8 | 4.25 | 6.35 | 7.6 | 12.6 | 14.8 | 8.5 | 6.45 | 6.6 | 6.8 | 7.1 | 6.95 |
| 19 | 3.9 | 4.2 | 5.9 | 7.6 | 12.1 | 15.2 | 8.55 | 6.45 | 6.9 | 6.8 | 7.0 | 6.9 |
| 20 | 4.2 | 4.1 | 5.8 | 7.6 | 11.9 | 15.4 | 8.65 | 6.25 | 6.7 | 6.75 | 6.9 | 6.9 |
| 21 | 4.15 | 4.2 | 5.9 | 7.9 | 12.3 | 15.0 | 8.75 | 6.2 | 6.6 | 6.7 | 6.85 | 6.9 |
| 22 | 4.5 | a4.2 | 5.9 | 8.1 | 12.75 | 15.0 | 8.6 | 6.1 | 6.75 | 6.7 | 6.85 | 6.85 |
| 23 | 4.4 | 4.2 | 5.8 | a8.4 | 13.4 | 14.35 | 8.55 | 6.3 | 7.2 | 6.7 | 6.9 | 6.75 |
| 24 | 4.3 | 4.2 | 5.8 | 8.8 | 13.7 | 13.8 | 8.35 | 6.6 | 7.0 | 6.65 | 6.85 | 6.65 |
| 25 | 4.4 | 4.3 | 5.8 | 8.9 | 14.2 | 13.1 | 8.15 | 6.2 | 6.9 | 6.6 | 6.85 | 6.55 |
| 26 | 4.5 | 4.3 | 6.5 | 9.2 | 14.2 | 12.4 | 8.05 | 6.2 | 7.0 | 6.6 | a6.85 | 6.45 |
| 27 | 4.4 | 4.3 | 6.4 | 9.8 | 14.55 | 11.85 | 7.85 | a6.25 | 7.0 | 6.55 | 6.85 | 6.4 |
| 28 | 4.45 | 4.4 | 6.3 | 10.4 | 14.5 | 11.6 | 7.65 | 6.35 | a7.2 | 6.6 | 6.9 | 6.4 |
| 29 | 4.4 | ..... | 6.55 | 10.3 | a14.2 | 11.2 | 7.55 | 6.45 | 7.4 | 6.75 | 6.9 | 6.5 |
| 30 | 4.4 | ..... | 7.3 | 10.0 | 13.9 | 10.6 | 7.55 | 6.5 | 7.6 | a6.75 | 6.8 | 6.55 |
| 31 | 4.3 | ..... | 7.75 | ..... | 13.4 | ..... | a7.5 | a6.5 | ..... | 6.75 | ..... | 6.5 |

a Estimated.

*Daily discharge, in second-feet, of Colorado River at Hardyville, Ariz., for 1905–6.*

| Day. | Jan | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905. | | | | | | | | | | | | |
| 1 | | | | | | 73,460 | 45,260 | 14,080 | 7,160 | 9,290 | 5,650 | 29,500 |
| 2 | | | | | | 70,700 | 44,020 | 14,080 | 7,160 | 11,600 | 5,400 | 26,500 |
| 3 | | | | | | 67,090 | 43,200 | 15,090 | 5,970 | 15,900 | 6,000 | 18,200 |
| 4 | | | | | | 63,550 | 40,750 | 16,110 | 5,970 | 13,100 | 5,750 | 14,300 |
| 5 | | | | | | 64,430 | 39,940 | 18,950 | 7,460 | 18,200 | 5,800 | 11,500 |
| 6 | | | | | | 73,920 | 37,120 | 17,500 | 8,065 | 15,600 | 5,550 | 10,400 |
| 7 | | | | | | 80,000 | 35,120 | 15,430 | 7,760 | 15,300 | 6,000 | 10,200 |
| 8 | | | | | | 85,780 | 32,750 | 15,430 | 8,370 | 14,300 | 8,500 | 9,500 |
| 9 | | | | | | 91,700 | 30,410 | 16,460 | 7,760 | 14,000 | 7,200 | 8,800 |
| 10 | | | | | | 98,780 | 30,410 | 14,750 | 8,370 | 12,000 | 7,000 | 7,400 |
| 11 | | | | | 31,580 | 97,760 | 28,850 | 14,080 | 10,850 | 10,300 | 6,000 | 6,300 |
| 12 | | | | | 31,970 | 94,700 | 26,160 | 12,770 | 8,980 | 8,900 | 6,500 | 6,300 |
| 13 | | | | | 32,360 | 97,760 | 25,000 | 12,440 | 7,760 | 7,900 | 6,200 | 6,700 |
| 14 | | | | | 33,940 | 99,290 | 23,840 | 11,800 | 7,760 | 7,200 | 5,200 | 6,700 |
| 15 | | | | | 33,940 | 99,800 | 18,950 | 10,850 | 7,460 | 6,200 | 6,700 | 6,000 |
| 16 | | | | | 32,360 | 92,700 | 23,840 | 10,850 | 7,460 | 6,000 | 6,100 | 6,000 |
| 17 | | | | | 30,410 | 87,740 | 21,180 | 10,220 | 7,160 | 5,300 | 5,800 | 6,000 |
| 18 | | | | | 31,190 | 82,880 | 19,690 | 9,600 | 6,560 | 5,600 | 5,900 | 6,000 |
| 19 | | | | | 32,360 | 80,000 | 19,320 | 9,600 | 5,970 | 5,600 | 5,980 | 5,300 |
| 20 | | | | | 32,750 | 77,180 | 18,950 | 9,600 | 5,970 | 5,200 | 6,000 | 5,390 |
| 21 | | | | | 35,520 | 73,920 | 18,220 | 9,290 | 5,090 | 4,850 | 5,400 | 5,600 |
| 22 | | | | | 41,560 | 69,340 | 18,220 | 9,290 | 5,090 | 4,800 | 5,500 | 6,000 |
| 23 | | | | | 47,330 | 64,430 | 18,220 | 8,370 | 4,800 | 4,800 | 5,600 | 6,700 |
| 24 | | | | | 53,230 | 61,810 | 17,150 | 8,370 | 5,090 | 5,050 | 6,350 | 6,700 |
| 25 | | | | | 56,640 | 58,790 | 16,460 | 8,370 | 4,515 | 4,700 | 5,760 | 6,700 |
| 26 | | | | | 62,680 | 57,500 | 15,430 | 15,770 | 4,515 | 5,400 | 17,800 | 7,830 |
| 27 | | | | | 67,090 | 53,230 | 15,430 | 8,980 | 4,515 | 5,050 | 17,300 | 7,400 |
| 28 | | | | | 70,700 | 49,840 | 15,430 | 7,160 | 4,515 | 5,700 | 14,500 | 7,400 |
| 29 | | | | | 81,920 | 50,680 | 15,430 | 6,560 | 10,540 | 6,050 | 13,200 | 7,400 |
| 30 | | | | | 79,060 | 54,080 | 15,090 | 7,160 | 10,540 | 5,900 | 13,300 | 6,700 |
| 31 | | | | | 76,240 | | 14,750 | 7,160 | | 5,900 | | 6,700 |
| 1906. | | | | | | | | | | | | |
| 1 | 3,430 | 6,100 | 6,700 | 33,600 | 45,900 | 83,500 | 62,600 | 25,000 | 15,500 | 17,800 | 8,300 | 7,720 |
| 2 | 3,000 | 5,600 | 6,000 | 36,900 | 42,900 | 91,700 | 59,000 | 25,000 | 13,200 | 16,000 | 8,000 | 6,800 |
| 3 | 3,100 | 5,200 | 6,000 | 32,800 | 41,800 | 95,500 | 55,000 | 29,000 | 12,500 | 17,500 | 8,600 | 6,700 |
| 4 | 2,900 | 5,250 | 5,700 | 27,300 | 41,300 | 94,300 | 51,000 | 27,000 | 13,500 | 16,800 | 9,470 | 6,000 |
| 5 | 2,850 | 5,110 | 5,700 | 27,100 | 36,400 | 95,000 | 50,500 | 24,400 | 13,000 | 16,600 | 8,900 | 5,500 |
| 6 | 3,100 | 5,000 | 5,650 | 23,600 | 34,000 | 96,500 | 47,500 | 21,500 | 13,000 | 15,800 | 9,200 | 6,000 |
| 7 | 3,440 | 5,300 | 5,600 | 21,100 | 34,000 | 94,500 | 48,700 | 18,500 | 12,200 | 13,500 | 9,500 | 10,100 |
| 8 | 3,150 | 5,300 | 5,700 | 21,500 | 28,500 | 93,200 | 47,000 | 20,700 | 13,600 | 12,800 | 9,500 | 23,100 |
| 9 | 3,050 | 5,700 | 5,650 | 21,300 | 35,600 | 91,200 | 47,500 | 18,800 | 13,600 | 12,100 | 10,000 | 14,500 |
| 10 | 3,300 | 6,100 | 5,600 | 22,100 | 42,500 | 92,000 | 44,100 | 19,100 | 13,600 | 11,700 | 12,800 | 13,000 |
| 11 | 3,200 | 6,200 | 5,700 | 22,800 | 52,700 | 93,200 | 41,000 | 20,500 | 12,000 | 12,000 | 12,700 | 12,600 |
| 12 | 3,250 | 6,400 | 5,800 | 22,900 | 58,500 | 95,800 | 39,600 | 17,800 | 12,600 | 12,300 | 12,500 | 12,400 |
| 13 | 3,200 | 6,200 | 6,700 | 27,000 | 65,800 | 91,000 | 39,000 | 18,000 | 12,100 | 12,000 | 12,200 | 11,700 |
| 14 | 3,500 | 6,200 | 7,500 | 26,100 | 72,800 | 100,000 | 34,500 | 17,500 | 12,100 | 12,000 | 11,300 | 11,300 |
| 15 | 3,450 | 6,000 | 10,600 | 24,600 | 71,500 | 100,000 | 34,600 | 17,200 | 12,100 | 11,700 | 10,700 | 11,300 |
| 16 | 3,700 | 6,050 | 15,000 | 25,200 | 77,100 | 101,000 | 33,500 | 17,300 | 11,700 | 11,100 | 10,600 | 10,100 |
| 17 | 4,500 | 6,100 | 19,300 | 25,700 | 78,000 | 105,000 | 36,000 | 17,600 | 11,300 | 10,800 | 10,300 | 9,100 |
| 18 | 4,800 | 5,900 | 19,000 | 27,200 | 72,300 | 110,000 | 35,700 | 16,200 | 12,000 | 10,300 | 10,200 | 9,100 |
| 19 | 5,200 | 5,800 | 15,400 | 27,200 | 68,000 | 115,000 | 36,500 | 16,500 | 15,000 | 10,200 | 9,600 | 9,000 |
| 20 | 5,700 | 5,600 | 14,300 | 27,300 | 63,700 | 116,000 | 37,200 | 14,000 | 12,500 | 9,840 | 9,200 | 9,000 |
| 21 | 5,900 | 5,850 | 14,900 | 30,200 | 68,500 | 113,000 | 39,700 | 13,500 | 10,800 | 9,800 | 9,000 | 9,000 |
| 22 | 7,300 | 5,900 | 14,300 | 32,200 | 73,500 | 113,000 | 38,500 | 12,500 | 11,800 | 9,300 | 9,200 | 8,900 |
| 23 | 7,000 | 6,000 | 13,500 | 34,100 | 81,000 | 106,000 | 38,000 | 15,000 | 16,500 | 9,200 | 9,400 | 8,300 |
| 24 | 6,700 | 6,050 | 13,200 | 37,100 | 83,000 | 100,000 | 35,700 | 20,300 | 14,000 | 8,900 | 9,430 | 7,600 |
| 25 | 7,200 | 6,350 | 12,800 | 38,300 | 89,500 | 93,000 | 33,600 | 14,200 | 12,500 | 8,500 | 9,200 | 7,000 |
| 26 | 7,700 | 6,300 | 18,000 | 41,700 | 89,500 | 85,000 | 32,600 | 14,000 | 13,000 | 8,450 | 9,200 | 6,700 |
| 27 | 7,300 | 6,300 | 17,600 | 48,600 | 92,200 | 79,700 | 30,500 | 14,100 | 13,000 | 8,200 | 9,200 | 6,400 |
| 28 | 7,700 | 6,700 | 17,200 | 55,600 | 93,000 | 76,700 | 28,500 | 15,000 | 15,000 | 8,400 | 9,500 | 6,400 |
| 29 | 7,200 | | 22,300 | 54,500 | 91,000 | 72,500 | 27,600 | 16,500 | 17,400 | 9,400 | 9,500 | 7,160 |
| 30 | 7,100 | | 26,800 | 51,200 | 89,000 | 66,000 | 27,500 | 16,500 | 19,500 | 9,400 | 8,800 | 7,100 |
| 31 | 6,700 | | 31,800 | | 84,500 | | 27,500 | 16,500 | | 9,400 | | 7,700 |

NOTE.—These discharges were obtained by the indirect method for shifting channels, except from May 11 to October 1, 1905, when a rating table was used.

*Estimated monthly discharge of Colorado River at Hardyville, Ariz., for 1905–6.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| 1905. | | | | |
| May (11 to 31) | 81,920 | 30,410 | 47,370 | 1,973,000 |
| June | 99,800 | 49,840 | 75,760 | 4,508,000 |
| July | 45,260 | 14,750 | 25,310 | 1,556,000 |
| August | 18,950 | 6,560 | 11,810 | 726,200 |
| September | 10,850 | 4,515 | 6,972 | 414,900 |
| October | 18,200 | 4,700 | 8,571 | 527,000 |
| November | 17,800 | 5,200 | 7,606 | 452,600 |
| December | 29,500 | 5,300 | 9,097 | 559,400 |
| The period | | | | 10,720,000 |
| 1906. | | | | |
| January | 7,700 | 2,850 | 4,830 | 297,000 |
| February | 6,700 | 5,000 | 5,880 | 327,000 |
| March | 31,800 | 5,600 | 12,300 | 756,000 |
| April | 55,600 | 21,100 | 31,600 | 1,880,000 |
| May | 93,000 | 28,500 | 64,500 | 3,970,000 |
| June | 116,000 | 66,000 | 95,300 | 5,670,000 |
| July | 62,600 | 27,500 | 40,000 | 2,460,000 |
| August | 29,000 | 12,500 | 18,400 | 1,130,000 |
| September | 19,500 | 10,800 | 13,400 | 797,000 |
| October | 17,800 | 8,200 | 11,700 | 719,000 |
| November | 12,800 | 8,000 | 9,870 | 587,000 |
| December | 23,100 | 5,500 | 9,260 | 569,000 |
| The year | 116,000 | 2,850 | 26,400 | 19,200,000 |

NOTE.—Values are rated as follows: October to December, 1905, fair; remainder of 1905 and 1906, good.

## COLORADO RIVER AT YUMA, ARIZ.

This station is located in the town of Yuma, Ariz., 1½ miles below the mouth of Gila River and 10 miles, by river, above the Mexican boundary. Records of river height have been kept by the Southern Pacific Company since April 1, 1878, on the gage which was established by Arthur Brown, superintendent of the company's bridge and building department, during the summer of 1876. The conditions at the station and the bench marks are described in Water-Supply Paper No. 177, page 13, where are given also references to publications that contain data for previous years.

*Discharge measurements of Colorado River at Yuma, Ariz., in 1906.*

[BY W. D. SMITH AND OTHERS.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| January 3 | 17.70 | 5,730 | February 21 | 19.40 | 10,800 |
| January 5 | 17.55 | 5,580 | February 24 | 19.30 | 10,200 |
| January 9 | 17.45 | 5,090 | March 6 | 18.90 | 8,600 |
| January 13 | 17.40 | 4,550 | March 9 | 18.90 | 7,730 |
| January 19 | 17.40 | 4,260 | March 12 | 18.85 | 6,740 |
| January 23 | 19.50 | 16,100 | March 15 | 26.35 | 54,300 |
| January 25 | 19.60 | 13,800 | March 16 | 27.55 | 66,700 |
| January 27 | 18.80 | 10,000 | March 17 | 24.75 | 42,300 |
| January 30 | 18.70 | 9,740 | March 19 | 22.75 | 33,200 |
| February 2 | 18.55 | 9,110 | March 21 | 22.05 | 24,600 |
| February 5 | 18.20 | 7,280 | March 24 | 21.50 | 22,400 |
| February 9 | 18.20 | 6,360 | March 27 | 24.00 | 43,800 |
| February 12 | 18.55 | 8,220 | March 28[a] | 26.50 | 65,600 |
| February 15 | 18.90 | 9,640 | March 29[a] | 28.10 | 75,000 |
| February 16 | 19.95 | 14,600 | March 31[a] | 23.70 | 34,700 |
| February 19 | 19.60 | 12,200 | April 3 | 23.80 | 37,500 |

[a] Measured by J. N. Johannson.

*Discharge measurements of Colorado River at Yuma, Ariz., in 1906*—Continued.

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| April 5 | 23.40 | 37,800 | August 27 | 19.10 | 15,200 |
| April 9 | 22.30 | 27,200 | August 29 | 19.50 | 16,400 |
| April 11 | 22.70 | 29,800 | August 31 | 18.90 | 13,400 |
| April 14 | 22.45 | 27,800 | September 3 | 19.20 | 14,500 |
| April 16 | 22.70 | 29,500 | September 5 | 18.85 | 12,500 |
| April 18 | 22.40 | 27,200 | September 7 | 18.70 | 12,000 |
| April 20 | 22.45 | 26,100 | September 10 | 18.75 | 11,800 |
| April 23 | 22.65 | 29,000 | September 13 | 18.80 | 11,800 |
| April 25 | 23.10 | 31,700 | September 15 | 18.70 | 10,700 |
| April 27 | 23.55 | 36,700 | September 17 | 16.65 | 10,700 |
| April 30 | 24.50 | 44,100 | September 19 | 18.40 | 9,920 |
| May 2 | 25.10 | 50,800 | September 21 | 18.40 | 10,200 |
| May 5 | 24.55 | 40,600 | September 24 | 18.40 | 10,300 |
| May 8 | 24.30 | 36,800 | September 26 | 19.10 | 13,200 |
| May 10 | 23.70 | 35,100 | September 28 | 18.70 | 11,700 |
| May 12 | 24.25 | 42,100 | October 1 | 19.55 | 15,900 |
| May 15 | 24.90 | 46,500 | October 3 | 19.40 | 14,700 |
| May 18 | 26.20 | 52,800 | October 6 | 19.35 | 15,800 |
| May 21 | 27.10 | 64,200 | October 8 | 19.10 | 14,900 |
| May 24 | 27.20 | 68,900 | October 10 | 18.80 | 14,300 |
| May 28 | 27.60 | 71,100 | October 11 | 18.60 | 13,300 |
| June 1 | 28.60 | 81,800 | October 16 | 18.10 | 10,700 |
| June 5 | 28.30 | 92,400 | October 18 | 18.10 | 10,800 |
| June 8 | 27.40 | 89,000 | October 22 | 18.00 | 9,950 |
| June 11 | 27.30 | 82,100 | October 24 | 18.00 | 9,800 |
| June 13 | 26.90 | 65,800 | October 27 | 18.00 | 8,980 |
| June 16 | 26.95 | 80,600 | October 29 | 18.05 | 8,610 |
| June 18 | 26.90 | 80,800 | November 1 | 18.35 | 8,630 |
| June 21 | 26.75 | 79,800 | November 3 | 18.50 | 9,150 |
| June 23 | 27.30 | 83,000 | November 6 | 18.65 | 8,430 |
| June 25 | 27.80 | 96,600 | November 8 | 18.75 | 9,420 |
| June 28 [a] | 28.05 | 96,900 | November 9 | 18.75 | 9,430 |
| June 30 | 27.30 | 80,300 | November 10 | 18.80 | 9,650 |
| July 3 | 24.35 | 60,400 | November 12 | 19.20 | 11,600 |
| July 5 | 22.85 | 48,100 | November 14 | 19.10 | 11,500 |
| July 9 | 21.85 | 40,400 | November 16 | 19.00 | 10,800 |
| July 11 | 21.80 | 38,600 | November 20 | 18.95 | 10,000 |
| July 13 | 21.40 | 38,100 | November 22 | 18.75 | 9,280 |
| July 16 | 20.95 | 35,400 | November 24 | 18.80 | 9,230 |
| July 18 | 21.15 | 32,900 | November 26 | 18.80 | 8,670 |
| July 20 | 21.30 | 32,400 | November 28 | 18.80 | 9,210 |
| July 23 | 21.60 | 31,600 | December 1 [b] | 18.70 | 9,080 |
| July 25 | 21.40 | 33,000 | December 3 | 18.65 | 9,080 |
| July 28 | 21.10 | 29,100 | December 5 | 18.50 | 8,470 |
| July 30 | 20.70 | 29,100 | December 6 | 21.10 | 26,000 |
| August 1 | 20.35 | 25,600 | December 8 | 23.90 | 47,000 |
| August 4 | 20.00 | 24,500 | December 10 | 21.90 | 37,000 |
| August 7 | 19.70 | 21,900 | December 11 | 21.00 | 28,200 |
| August 9 | 19.30 | 22,000 | December 12 | 20.30 | 23,400 |
| August 11 | 19.55 | 20,500 | December 15 | 19.60 | 18,300 |
| August 13 | 19.40 | 19,500 | December 17 [c] | 19.30 | 15,800 |
| August 15 | 19.20 | 16,900 | December 19 | 19.10 | 13,900 |
| August 18 | 19.10 | 16,500 | December 21 | 18.90 | 12,300 |
| August 20 | 19.25 | 16,400 | December 24 | 18.80 | 11,300 |
| August 21 | 19.90 | 18,500 | December 26 | 18.60 | 10,600 |
| August 24 | 19.20 | 15,500 | December 28 | 18.50 | 8,870 |
| August 25 | 19.80 | 17,900 | December 29 | 18.50 | 8,940 |

[a] Measurements June 28 to July 25 by F. R. S. Buttemer.
[b] Measurements December 1 to 15 by J. M. Brown.
[c] Measurements December 17 to 29 by L. C. Robertson.

*Daily gage height, in feet, of Colorado River at Yuma, Ariz., for 1903.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 17.75 | 18.6 | 19.0 | 24.2 | 24.75 | 28.6 | 26.5 | 20.35 | 18.8 | 19.55 | 18.35 | 18.7 |
| 2 | 17.7 | 18.55 | 19.0 | 23.9 | 25.1 | 28.6 | 25.55 | 20.3 | 19.0 | 19.4 | 18.5 | 18.8 |
| 3 | 17.7 | 18.55 | 19.0 | 23.8 | 25.0 | 28.8 | 24.35 | 20.2 | 19.2 | 19.4 | 18.5 | 18.65 |
| 4 | 17.6 | 18.45 | 19.0 | 24.0 | 24.7 | 28.6 | 23.35 | 20.0 | 19.1 | 19.45 | 18.6 | 18.6 |
| 5 | 17.55 | 18.2 | 18.95 | 23.4 | 24.55 | 28.3 | 22.85 | 20.15 | 18.85 | 19.45 | 18.6 | 18.5 |
| 6 | 17.4 | 18.3 | 18.9 | 23.2 | 24.55 | 27.95 | 22.4 | 20.0 | 18.7 | 19.35 | 18.65 | 20.3 |
| 7 | 17.4 | 18.2 | 18.95 | 22.95 | 24.4 | 27.6 | 22.0 | 19.7 | 18.7 | 19.15 | 18.7 | 25.3 |
| 8 | 17.5 | 18.2 | 18.95 | ..... | 24.2 | 27.4 | 21.9 | 19.4 | 18.7 | 19.1 | 18.75 | 23.55 |
| 9 | 17.45 | 18.2 | 18.9 | 22.45 | 23.95 | 27.4 | 21.85 | 19.3 | 18.65 | 18.9 | 18.8 | 21.2 |
| 10 | 17.5 | 18.2 | 18.85 | 22.9 | 23.8 | 27.45 | 21.85 | 19.2 | 18.75 | 18.8 | 18.8 | 22.1 |

*Daily gage height, in feet, of Colorado River at Yuma, Ariz., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 17.5 | 18.7 | 18.85 | 22.7 | 23.8 | 27.3 | 21.8 | 19.55 | 18.8 | 18.6 | 18.85 | 20.9 |
| 12 | 17.5 | 18.55 | 18.85 | 22.65 | 24.25 | 27.1 | 21.55 | 19.4 | 18.85 | 18.4 | 19.2 | 20.3 |
| 13 | 17.4 | 18.7 | 18.9 | 22.6 | 24.3 | 26.9 | 21.4 | 19.4 | 18.8 | 18.25 | 19.3 | 20.05 |
| 14 | 17.4 | 18.8 | 20.2 | 22.45 | 24.5 | 26.7 | 21.3 | 19.4 | 18.8 | 18.25 | 19.1 | 19.8 |
| 15 | 17.4 | 18.9 | 26.2 | 22.9 | 24.9 | 26.75 | 21.1 | 19.2 | 18.7 | 18.2 | 19.1 | 19.5 |
| 16 | 17.4 | 19.95 | 27.55 | 22.7 | 25.4 | 26.95 | 20.95 | 19.2 | 18.7 | 18.1 | 19.0 | 19.3 |
| 17 | 17.4 | 20.0 | 25.5 | 22.4 | 25.85 | 26.95 | 20.95 | 19.1 | 18.65 | 18.1 | 18.95 | 19.3 |
| 18 | 17.4 | 19.8 | 23.2 | 22.4 | 26.2 | 26.9 | 21.25 | 19.1 | 18.6 | 18.1 | 18.9 | 19.15 |
| 19 | 17.4 | 19.6 | 22.65 | 22.55 | 26.45 | 26.8 | 21.5 | 19.5 | 18.4 | 18.1 | 18.9 | 19.05 |
| 20 | 17.45 | 19.4 | 22.85 | 22.45 | 26.8 | 26.7 | 21.2 | 19.25 | 18.35 | 18.0 | 18.9 | 19.01 |
| 21 | 17.4 | 19.4 | 22.05 | 22.4 | 27.1 | 26.75 | 21.35 | 19.9 | 18.45 | 18.0 | 18.9 | 18.9 |
| 22 | 17.5 | 19.4 | 21.7 | 22.4 | 27.2 | 26.85 | 21.5 | 19.3 | 18.6 | 18.0 | 18.8 | 19.0 |
| 23 | 19.5 | 19.3 | 21.6 | 22.7 | 27.3 | 27.3 | 21.6 | 19.25 | 18.6 | 18.0 | 18.8 | 18.9 |
| 24 | 19.4 | 19.3 | 21.5 | 22.9 | 27.2 | 27.6 | 21.5 | 19.2 | 18.4 | 18.0 | 18.8 | 18.8 |
| 25 | 19.6 | 19.2 | 21.35 | 23.1 | 27.2 | 27.8 | 21.4 | 19.8 | 18.7 | 17.95 | 18.8 | 18.7 |
| 26 | 19.0 | 19.1 | 21.2 | 23.5 | 27.3 | 27.85 | 21.4 | 19.45 | 19.1 | 17.95 | 18.8 | 18.6 |
| 27 | 18.8 | 19.0 | 23.1 | 23.55 | 27.5 | 28.10 | 21.2 | 19.15 | 18.8 | 18.0 | 18.75 | 18.5 |
| 28 | 18.75 | 19.0 | 26.0 | 23.8 | 27.6 | 28.05 | 21.1 | 18.9 | 18.7 | 18.0 | 18.8 | 18.5 |
| 29 | 18.75 | ..... | 27.95 | 24.2 | 27.8 | 27.85 | 20.9 | 19.5 | 18.8 | 18.05 | 18.75 | 18.5 |
| 30 | 18.7 | ..... | 25.0 | 24.5 | 28.2 | 27.3 | 20.7 | 19.2 | 19.0 | 18.1 | 18.8 | 18.4 |
| 31 | 18.7 | ..... | 23.8 | ..... | 28.4 | ..... | 20.5 | 18.9 | ..... | 18.15 | ..... | 24.55 |

*Daily discharge, in second-feet, of Colorado River at Yuma, Ariz., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5,800 | 9,280 | 9,350 | 39,600 | 46,900 | 81,800 | 74,200 | 25,600 | 12,700 | 15,900 | 8,630 | 9,080 |
| 2 | 5,800 | 9,100 | 9,210 | 37,600 | 50,800 | 84,000 | 68,000 | 25,500 | 13,300 | 15,000 | 9,300 | 9,080 |
| 3 | 5,730 | 9,000 | 9,070 | 37,500 | 48,600 | 84,200 | 60,400 | 25,200 | 14,500 | 14,760 | 9,150 | 9,080 |
| 4 | 5,640 | 8,500 | 8,900 | 38,000 | 43,400 | 87,200 | 52,200 | 24,500 | 13,800 | 15,160 | 9,270 | 9,000 |
| 5 | 5,580 | 7,280 | 8,750 | 37,800 | 40,600 | 92,400 | 48,100 | 24,960 | 12,500 | 15,200 | 8,700 | 8,470 |
| 6 | 5,460 | 7,500 | 8,600 | 35,900 | 41,000 | 91,100 | 44,600 | 24,400 | 12,100 | 15,800 | 8,430 | 17,800 |
| 7 | 5,280 | 6,800 | 8,350 | 33,400 | 38,500 | 89,800 | 41,960 | 21,900 | 12,000 | 15,000 | 9,000 | 60,600 |
| 8 | 5,230 | 6,600 | 8,050 | 31,000 | 36,800 | 89,000 | 41,100 | 21,900 | 11,900 | 14,900 | 9,420 | 43,900 |
| 9 | 5,090 | 6,360 | 7,730 | 27,200 | 35,000 | 86,700 | 40,400 | 22,000 | 11,900 | 14,500 | 9,700 | 27,900 |
| 10 | 4,950 | 6,450 | 7,300 | 32,200 | 35,100 | 85,300 | 39,500 | 21,900 | 11,800 | 14,300 | 9,650 | 38,700 |
| 11 | 4,830 | 8,860 | 6,900 | 29,800 | 36,700 | 82,100 | 38,600 | 20,500 | 11,800 | 13,300 | 9,800 | 27,400 |
| 12 | 4,700 | 8,220 | 6,740 | 29,200 | 42,100 | 74,000 | 40,600 | 19,700 | 11,900 | 11,800 | 11,600 | 23,400 |
| 13 | 4,550 | 8,840 | 7,000 | 29,000 | 42,800 | 65,800 | 38,100 | 19,500 | 11,800 | 10,900 | 12,500 | 21,600 |
| 14 | 4,500 | 9,250 | 15,600 | 27,800 | 44,000 | 65,000 | 37,400 | 19,200 | 11,750 | 10,800 | 11,500 | 19,800 |
| 15 | 4,450 | 9,640 | 54,300 | 31,200 | 46,500 | 70,000 | 36,300 | 16,900 | 10,700 | 10,500 | 11,500 | 17,500 |
| 16 | 4,400 | 14,600 | 66,700 | 29,500 | 48,900 | 80,600 | 35,400 | 16,800 | 10,700 | 10,700 | 11,400 | 15,900 |
| 17 | 4,350 | 14,800 | 42,300 | 27,200 | 51,100 | 80,600 | 34,600 | 16,600 | 10,700 | 10,800 | 10,500 | 15,800 |
| 18 | 4,300 | 13,500 | 35,000 | 27,200 | 52,800 | 80,800 | 32,900 | 16,500 | 10,500 | 10,800 | 10,200 | 14,500 |
| 19 | 4,200 | 12,200 | 33,200 | 28,200 | 55,900 | 80,400 | 32,600 | 17,500 | 9,900 | 10,700 | 9,900 | 13,860 |
| 20 | 4,600 | 11,000 | 33,500 | 26,100 | 60,200 | 80,100 | 32,400 | 16,400 | 9,600 | 10,300 | 9,750 | 13,200 |
| 21 | 4,400 | 10,800 | 24,600 | 25,800 | 64,200 | 79,800 | 32,200 | 18,500 | 10,200 | 10,100 | 9,850 | 12,300 |
| 22 | 5,000 | 10,700 | 23,300 | 25,500 | 66,000 | 80,400 | 31,800 | 18,100 | 10,900 | 10,000 | 9,300 | 12,800 |
| 23 | 16,100 | 10,300 | 22,800 | 29,000 | 67,700 | 83,000 | 31,600 | 15,800 | 11,000 | 9,800 | 9,330 | 12,900 |
| 24 | 14,600 | 10,200 | 22,400 | 39,600 | 68,900 | 91,000 | 32,300 | 15,500 | 10,300 | 9,800 | 9,230 | 11,300 |
| 25 | 13,800 | 9,880 | 21,200 | 31,700 | 69,200 | 96,600 | 33,000 | 17,900 | 11,500 | 9,500 | 8,900 | 11,000 |
| 26 | 11,000 | 9,550 | 19,000 | 36,200 | 69,700 | 96,400 | 32,400 | 16,400 | 13,200 | 9,200 | 8,670 | 10,600 |
| 27 | 10,000 | 9,250 | 43,800 | 36,700 | 70,600 | 99,200 | 30,800 | 15,200 | 12,100 | 9,000 | 8,700 | 9,500 |
| 28 | 9,940 | 9,190 | 65,600 | 38,600 | 71,200 | 97,100 | 29,100 | 14,300 | 11,700 | 8,800 | 9,210 | 8,870 |
| 29 | 9,830 | ..... | 75,000 | 41,800 | 73,500 | 92,000 | 29,100 | 16,400 | 12,200 | 8,600 | 9,000 | 8,000 |
| 30 | 9,740 | ..... | 47,500 | 44,100 | 77,300 | 79,300 | 29,100 | 15,000 | 13,300 | 8,600 | 9,080 | 6,800 |
| 31 | 9,600 | ..... | 34,700 | ..... | 79,800 | ..... | 27,000 | 13,400 | ..... | 8,600 | ..... | 48,900 |

NOTE.—These discharges were obtained by the indirect method for shifting channels.

*Monthly discharge of Colorado River at Yuma, Ariz., for 1906.*

[Drainage area, 225,000 square miles.]

| Month. | Discharge in second-feet. | | | Run-off. | | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Total in acre-feet. | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 16,100 | 4,260 | 6,870 | 422,000 | 0.030 | 0.03 |
| February | 14,800 | 6,360 | 9,560 | 531,000 | 0.042 | .04 |
| March | 75,000 | 6,740 | 25,400 | 1,560,000 | 0.113 | .13 |
| April | 44,100 | 25,500 | 32,500 | 1,930,000 | 0.144 | .16 |
| May | 79,800 | 35,100 | 54,100 | 3,330,000 | 0.240 | .28 |
| June | 99,200 | 65,000 | 84,200 | 5,010,000 | 0.374 | .42 |
| July | 74,200 | 27,000 | 39,000 | 2,400,000 | 0.173 | .20 |
| August | 25,600 | 13,400 | 19,200 | 1,180,000 | 0.085 | .10 |
| September | 14,500 | 9,600 | 11,700 | 696,000 | 0.052 | .06 |
| October | 15,900 | 8,600 | 11,700 | 719,000 | 0.052 | .06 |
| November | 12,500 | 8,430 | 9,710 | 578,000 | 0.043 | .05 |
| December | 60,000 | 6,800 | 18,300 | 1,130,000 | 0.081 | .09 |
| The year | 99,200 | 4,260 | 26,900 | 19,490,000 | 0.119 | 1.62 |

NOTE.—These values are good.

## MISCELLANEOUS MEASUREMENTS IN COLORADO RIVER DRAINAGE BASIN.

The following miscellaneous measurements were made in Colorado River drainage basin below Hardyville in 1906:

*Colorado River below heading No. 3 of Imperial canal.*—Measurements at this point show the discharge in the old channel of Colorado River below the intake of the Imperial canal, where most of the flow was diverted into Salton Sea.

There was practically no discharge in the old channel from early in July until the closure of the break, in November, 1906. The conditions at this point are described in Water-Supply Paper No. 177, page 17.

*Discharge measurements of Colorado River below heading No. 3 of Imperial canal in 1906.*

| Date. | Hydrographer. | Gage height. | Discharge. | Date. | Hydrographer. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|
| | | *Feet.* | *Sec.-ft.* | | | *Feet.* | *Sec.-ft.* |
| April 10 | W. D. Smith | 4.90 | 1,760 | June 7 | W. D. Smith | 7.00 | 3,210 |
| April 24 | do | 4.60 | 974 | June 19 | do | 6.30 | 398 |
| May 4 | do | 5.60 | 2,040 | June 27 | Smith and Buttemer | 7.10 | [a]1,220 |
| May 14 | do | 5.10 | 1,040 | July 4 | F. R. S. Buttemer | 4.50 | 34 |
| May 22 | do | 6.70 | 3,840 | July 11 | do | 3.80 | 0 |
| May 29 | do | 6.80 | 3,440 | | | | |

[a] Second channel estimated.

*Farmer's canal near Yuma, Ariz.*—This canal diverts water from Colorado River about 1 mile below Yuma. Measurements were made at the heading. The canal was dry after July 4.

June 7: Area, 82 square feet; discharge, 58 second-feet.

June 19: Area, 78 square feet; discharge, 48 second-feet.

*Ludy canal near Yuma, Ariz.*—This canal diverts water from Colorado River about 3 miles below Yuma. Measurements were made at the heading. The canal was dry after July 4.

June 7: Area, 109 square feet; discharge, 76 second-feet.

June 19: Area, 116 square feet; discharge, 93 second-feet.

SALTON SEA NEAR SALTON, CAL.

What is now generally known as Salton Sea was until recently an old dry lake or playa, marked on maps as Salton Sink. There is some uncertainty as to the elevation of the lowest point of this sink, and it is now believed that the depth below sea level has been overestimated in the past. From the record of the depth of the water as it filled the lowest portion of the basin, as kept by the New Liverpool Salt Company, it appears that the maximum depth of water was 17 feet on October 4, 1905 (according to the gage and as checked by soundings later), when on the same date the water surface just covered the United States Geological Survey bench mark a few feet from the old Salton railway station. As this bench mark is 256.5 feet below mean sea level, it would appear that the lowest point of the sink is 273.5 feet below mean sea level instead of 287 feet, which has been accepted heretofore.

Salton Sink originally formed a part of the Colorado Desert, which has an area of nearly 2,000 square miles and extends in a northwesterly direction almost 100 miles from the California-Mexico boundary line. It comprises two fertile valleys, that to the northwest of the sink, in Riverside County, being known as the Coahuila Valley, and the one to the southeast of the sink, in San Diego County, being called the Imperial Valley. Salton Sea, which now partly fills the sink, separates the two valleys and is partly in Riverside County and partly in San Diego County. The longest diameter of the sea has a northwest-southeast direction. On December 31, 1906, its surface was 201 feet below mean sea level and it had a length of nearly 50 miles, a maximum width of about 16 miles, a minimum width of 10 miles, a maximum depth of 72.5 feet, and a superficial area of about 462 square miles. It is about 160 miles southeast of Los Angeles, 90 miles northwest of Yuma, and 50 miles north of Calexico.

A few thousand years ago, according to geologic evidence, what is now Salton Sea was a part of the Gulf of California, which then extended about 200 miles further northwest than at present, reaching possibly to the base of San Jacinto and San Gorgonio mountains, and certainly some distance beyond the present town of Indio. Colorado River then emptied into the Gulf about 125 miles below its head in the vicinity of Yuma, 75 miles above the present mouth. The river, then as now, was heavily laden with silt, at present estimated to amount to about 53 mile-feet annually, or sufficient to cover 53 square miles 1 foot deep each year. The checking of the velocity near the river's mouth owing to the practically still water of the Gulf, resulted in a deposition of this vast volume of silt, and in the course of hundreds of years built up a broad delta that extended westward as a wide bar or dam until it eventually reached the Cocopa Mountains in Mexico, the western wall of the valley, forming an

inland salt, or brackish, sea. During the next few hundred years the Colorado delivered all, or a part, of its silt-laden waters into this newly formed sea, raising the level of its waters coincidently with elevating, broadening, and strengthening by the silt-depositing process the barrier dam which effected its complete and permanent isolation. In the course of many years the dam and the level of the inland sea reached a height of about 30 feet above mean sea level, whereupon the river took a course of less resistance and found an outlet to the Gulf below the recently completed dam.

Whether the river maintained its outlet to the Gulf continuously until the inland sea was completely dissipated through the medium of evaporation is not known. The probability is that the river followed the course of all rivers with growing deltas, and changed its channel from time to time with more or less caprice, alternately discharging into the Gulf and the inland sea. At any rate it is definitely known from the shells found on the desert that the water which ultimately filled the inland sea was fresh, while the originally isolated Gulf water was salt. The conversion from salt to fresh water may have come about through the alternate partial evaporation of the salt water and the refilling with fresh water from the river, or it may have been effected gradually by means of dilution and substitution from a continuous fresh-water inflow covering a long period of time.

As to the date when this inland sea finally disappeared there is no definite information. The Indians now living in the desert are said to have a tradition that the sea was full as late as 400 or 500 years ago at most, and that the water disappeared "poco a' poco"—little by little—until the sea became dry. The geologic evidence at hand neither confirms nor disproves the Indian legend, but simply indicates that the dissipation of the sea occurred at a time which, if not historic, is at least one of the most recent of geologic dates. With climatic conditions as they are at present the sea when full would probably have evaporated in 50 years if not checked by inflow. It is highly probable that the sink has been partly refilled many times in the recent past, the water soon evaporating. During the summer of 1891 the high water in the Colorado overflowed into the sink to such an extent as to endanger the Southern Pacific's railway at its lowest point. In the summer of 1905, after a succession of winter and spring floods in Gila River, followed by an exceptionally heavy summer flow in the Colorado, there was a repetition of flood conditions in the sink on a much larger scale.

The gravity of the situation on this latter date, however, was greatly augmented by the interference of man. For several years preceding a small quantity of water had been diverted from the Colorado below Yuma, Ariz., to be used by the settlers of the Imperial Valley for irrigation and domestic purposes. The first water

was diverted in the United States and conveyed to the Imperial Valley, after passing through Mexican territory, by means of an old river channel which had been one of the Colorado's distributaries during the formation of its delta, and is now known as Alamo River. The increased demand for water and the silting up of the original canal heading above the boundary line necessitated the cutting of an additional channel from the river below the boundary to connect with the canal. It likewise silted up, so that in order to supply the urgent need for water a canal was cut 4 miles below the original heading to connect Colorado and Alamo rivers. This canal was not provided with protective headworks and had a gradient much greater than that of the river, so that with the unusual and prolonged summer flood in 1905, it began cutting, until in July it was carrying 87 per cent of the total flow of the river. This large quantity of water flooded several hundred square miles about Calexico in the southern part of the Imperial Valley, and caused serious loss both in the United States and in Mexico. These waters ultimately reached the Salton Sea but in doing so they deepened and widened Alamo River into a great gorge and developed another drainage channel to the west through Imperial Valley in a second gorge now called New River. Notwithstanding all attempts to control it the Colorado continued to pour its waters through Alamo and New rivers into Salton Sea until the early fall of 1906 when it was finally shut off by the Southern Pacific Company. It broke again, however, on December 7, but was closed about two months later.

The rise of Salton Sea began in November, 1904, and continued throughout 1905 and 1906. In the summer of 1905 it endangered the Southern Pacific tracks to such an extent as to require frequent shifting to higher ground by means of "shoo-fly" or spur tracks, which served temporarily until the latter part of the year when a high line about 40 miles in length was completed on the 200-foot contour below sea level. This line is still in use, though during the latter part of 1906 the lowest portion of it was seriously damaged by the action of waves. For use in the future, if required, another line has been located and graded on the 150-foot contour below sea level. In addition to the damage done to the railroad the sea has completely submerged the plant of the New Liverpool Salt Company, below Mecca, and also a few ranches in the vicinity of Mecca.

The gage record from November, 1904, to February 26, 1906, was kept by the New Liverpool Salt Company. Their datum is the lowest portion of the sink, or at least that portion which first filled with water, so that the gage record shows the actual depth of the water from time to time. On February 23, 1906, the government put in a gage on the same datum about one-half mile west of Salton railway station, which is 3 miles southeast of the old Salton station. This gage consisted of a series of 5 posts, 6 inches by 6 inches by 6

feet, set in the ground about 3 feet deep, and so placed that when the water covered one it would just reach the next one farther back. It was not a great while, however, until the waves completely destroyed this gage. In the meantime the Southern Pacific Company had graduated a bent on the trestle bridge across Salt Creek, about 2½ miles east of Salton, using the company's datum, and arrangements were made to have the Southern Pacific agent at Salton furnish the record from this gage, corrections being made to reduce to the original datum. The zero of the gage is 273.5 feet below mean sea level as determined from United States Geological Survey bench marks, or at an elevation of −280.3 according to the Southern Pacific Company.

*Daily gage height, in feet, of Salton Sea near Salton, Cal., for 1904–1906.*

| Day. | Nov. | Dec. | Day. | Nov. | Dec. | Day. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| 1904. | | | 1904. | | | 1904. | | |
| 1 | 0.0 | 0.6 | 13 | 0.0 | 0.7 | 25 | 0.4 | 0.6 |
| 2 | .0 | .6 | 14 | .0 | .7 | 26 | .4 | .1 |
| 3 | .0 | .6 | 15 | .2 | .7 | 27 | .5 | .0 |
| 4 | .0 | .6 | 16 | .2 | .7 | 28 | .5 | .8 |
| 5 | .0 | .2 | 17 | .3 | .7 | 29 | .6 | .8 |
| 6 | .0 | .0 | 18 | .3 | .7 | 30 | .6 | .8 |
| 7 | .0 | .3 | 19 | .3 | .7 | 31 | | .8 |
| 8 | .0 | .7 | 20 | .4 | .7 | | | |
| 9 | .0 | .7 | 21 | .5 | .7 | Total monthly rise | .6 | .2 |
| 10 | .0 | .7 | 22 | .5 | .7 | | | |
| 11 | .0 | .7 | 23 | .4 | .7 | | | |
| 12 | .0 | .7 | 24 | .4 | .6 | | | |

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905. | | | | | | | | | | | | |
| 1 | 0.8 | 2.2 | 3.8 | 4.8 | 5.7 | 7.0 | 9.1 | 13.5 | 15.7 | 16.8 | 18.3 | 19.8 |
| 2 | .7 | 2.2 | 3.9 | 4.8 | 5.8 | 7.1 | 9.2 | 13.8 | 15.7 | 16.9 | 18.3 | 19.8 |
| 3 | .6 | 2.3 | 4.0 | 4.8 | 5.9 | 7.0 | 9.4 | 13.8 | 15.7 | 16.9 | 18.4 | 19.9 |
| 4 | .6 | 2.4 | 4.2 | 4.9 | 6.0 | 7.1 | 9.6 | 13.8 | 15.7 | 17.0 | 18.5 | 19.9 |
| 5 | .6 | 2.4 | 4.4 | 5.0 | 5.8 | 7.2 | 9.7 | 13.8 | 15.7 | 17.0 | 18.5 | 20.0 |
| 6 | .7 | 2.4 | 4.4 | 5.2 | 5.8 | 7.3 | 9.8 | 13.8 | 15.8 | 17.1 | 18.6 | 20.1 |
| 7 | .7 | 2.5 | 4.4 | 5.3 | 6.2 | 7.6 | 10.1 | 14.0 | 15.8 | 17.1 | 18.7 | 20.2 |
| 8 | .8 | 2.6 | 4.4 | 5.2 | 6.1 | 7.2 | 10.2 | 14.1 | 15.8 | 17.1 | 18.8 | 20.3 |
| 9 | .8 | 2.7 | 4.4 | 5.4 | 6.0 | 7.3 | 10.3 | 14.2 | 15.8 | 17.1 | 18.8 | 20.5 |
| 10 | .9 | 2.8 | 4.3 | 5.2 | 5.8 | 7.6 | 10.3 | 14.2 | 15.9 | 17.2 | 18.8 | 20.7 |
| 11 | 1.0 | 2.8 | 4.3 | 5.2 | 6.2 | 7.5 | 10.7 | 14.2 | 15.9 | 17.2 | 18.8 | 20.8 |
| 12 | 1.0 | 2.8 | 4.3 | 5.3 | 6.2 | 7.7 | 10.8 | 14.4 | 16.0 | 17.2 | 18.9 | 21.0 |
| 13 | 1.1 | 2.9 | 4.3 | 5.4 | 6.2 | 7.7 | 10.9 | 14.3 | 16.0 | 17.2 | 19.0 | 21.2 |
| 14 | 1.1 | 3.0 | 4.2 | 5.5 | 6.3 | 7.7 | 10.9 | 14.4 | 16.1 | 11.2 | 19.0 | 21.3 |
| 15 | 1.1 | 3.2 | 4.2 | 5.4 | 6.3 | 7.8 | 11.1 | 14.5 | 16.1 | 17.3 | 19.1 | 21.5 |
| 16 | 1.7 | 3.2 | 4.2 | 5.5 | 6.4 | 7.8 | 11.2 | 14.6 | 16.2 | 17.3 | 19.2 | 21.7 |
| 17 | 1.8 | 3.2 | 4.6 | 5.3 | 6.4 | 7.8 | 11.4 | 14.7 | 16.2 | 17.4 | 19.2 | 21.8 |
| 18 | 1.8 | 3.2 | 4.6 | 5.5 | 6.4 | 7.8 | 11.7 | 14.8 | 16.2 | 17.5 | 19.2 | 21.9 |
| 19 | 1.8 | 3.3 | 4.6 | 5.2 | 6.5 | 8.0 | 11.9 | 14.8 | 16.2 | 18.0 | 19.2 | 22.0 |
| 20 | 1.8 | 3.3 | 4.5 | 5.5 | 6.6 | 8.0 | 11.9 | 14.9 | 16.3 | 17.7 | 19.3 | 22.1 |
| 21 | 1.8 | 3.4 | 4.5 | 5.4 | 6.5 | 8.2 | 12.1 | 15.0 | 16.3 | 17.8 | 19.3 | 22.2 |
| 22 | 1.8 | 3.4 | 4.5 | 5.7 | 6.7 | 8.2 | 12.2 | 15.0 | 16.4 | 17.8 | 19.4 | 22.2 |
| 23 | 1.8 | 3.4 | 4.6 | 5.7 | 6.5 | 8.3 | 12.4 | 15.1 | 16.4 | 17.9 | 19.4 | 22.3 |
| 24 | 1.9 | 3.4 | 4.6 | 5.7 | 6.8 | 8.4 | 12.5 | 15.2 | 16.5 | 17.9 | 19.5 | 22.3 |
| 25 | 2.0 | 3.5 | 4.6 | 5.5 | 6.6 | 8.5 | 12.7 | 15.2 | 16.5 | 18.0 | 19.5 | 22.4 |
| 26 | 2.0 | 3.6 | 4.6 | 5.6 | 6.6 | 8.5 | 12.8 | 15.3 | 16.6 | 18.0 | 19.6 | 22.4 |
| 27 | 2.0 | 3.7 | 4.6 | 5.7 | 6.6 | 8.7 | 13.0 | 15.4 | 16.7 | 18.1 | 19.7 | 22.5 |
| 28 | 2.0 | 3.8 | 4.7 | 5.8 | 6.8 | 8.8 | 13.1 | 15.5 | 16.8 | 18.2 | 19.7 | 22.6 |
| 29 | 2.1 | ..... | 4.6 | 5.8 | 6.8 | 8.8 | 13.2 | 15.5 | 16.8 | 18.2 | 19.8 | 22.6 |
| 30 | 2.1 | ..... | 4.6 | 5.8 | 7.0 | 9.0 | 13.2 | 15.6 | 16.8 | 18.2 | 19.8 | 22.7 |
| 31 | 2.2 | ..... | 4.6 | ..... | 6.8 | ..... | 13.4 | 15.6 | ..... | 18.2 | ..... | 22.7 |
| Total monthly rise | 1.4 | 1.6 | .8 | 1.2 | 1.0 | 2.2 | 4.4 | 2.2 | 1.2 | 1.4 | 1.6 | 2.9 |

*Daily gage height, in feet, of Salton sea near Salton, Cal., for 1904–1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906. | | | | | | | | | | | | |
| 1 | 22.8 | 23.9 | ..... | 28.3 | 34.1 | 42.7 | 59.1 | 66.7 | 69.5 | 70.3 | 71.5 | 71.3 |
| 2 | 22.8 | 24.0 | 25.6 | ..... | ..... | 43.3 | 59.4 | 66.9 | 69.5 | 70.3 | 71.5 | 71.3 |
| 3 | 22.8 | 24.0 | ..... | 28.7 | 34.4 | 43.8 | 60.1 | 67.0 | 69.6 | 70.3 | 71.5 | 71.2 |
| 4 | 22.8 | 24.2 | ..... | ..... | 34.5 | 44.4 | 60.3 | 67.0 | 69.6 | 70.4 | 71.5 | 71.2 |
| 5 | 22.9 | 24.2 | 25.8 | 29.1 | ..... | 44.7 | 60.5 | 67.1 | 69.7 | 70.4 | 71.6 | 71.2 |
| 6 | 22.9 | 24.3 | ..... | ..... | ..... | ..... | 61.0 | 67.2 | 69.8 | 70.4 | 71.6 | 71.2 |
| 7 | 23.0 | 24.4 | 25.9 | 29.5 | ..... | ..... | 61.4 | 67.3 | 69.9 | 70.4 | 71.6 | 71.2 |
| 8 | 23.0 | 24.4 | 26.0 | 29.7 | ..... | ..... | 61.7 | 67.4 | 69.9 | 70.6 | 71.6 | 71.2 |
| 9 | 23.1 | 24.5 | ..... | ..... | ..... | ..... | 62.1 | 67.5 | 69.9 | 70.6 | 71.6 | 71.2 |
| 10 | 23.1 | 24.5 | 26.0 | 30.2 | ..... | 47.9 | 62.3 | 67.6 | 69.9 | 70.8 | 71.6 | 71.2 |
| 11 | 23.2 | 24.7 | ..... | ..... | ..... | 48.4 | 62.6 | 67.7 | 69.9 | 70.9 | 71.6 | 71.2 |
| 12 | 23.2 | 24.8 | 26.0 | 30.5 | 36.4 | 48.6 | 62.8 | 67.8 | 70.0 | 71.1 | 71.6 | 71.2 |
| 13 | 23.2 | 24.8 | 26.2 | 30.9 | ..... | 49.5 | 63.3 | 67.9 | 70.0 | 71.3 | 71.6 | 71.4 |
| 14 | 23.2 | 24.9 | ..... | 31.1 | 36.9 | 50.0 | 63.3 | 68.1 | 70.0 | 71.3 | 71.6 | 71.4 |
| 15 | 23.3 | 25.0 | ..... | 31.3 | 37.2 | ..... | 63.5 | 68.2 | 70.1 | 71.3 | 71.6 | 71.5 |
| 16 | 23.3 | 25.0 | ..... | ..... | ..... | 51.3 | 63.8 | 68.3 | 70.1 | 71.3 | 71.5 | 71.5 |
| 17 | 23.3 | 25.1 | 26.3 | 31.7 | 37.5 | ..... | 64.1 | 68.4 | 70.1 | 71.3 | 71.5 | 71.5 |
| 18 | 23.3 | 25.1 | 26.4 | ..... | 37.8 | 52.3 | 64.3 | 68.5 | 70.1 | 71.3 | 71.5 | 71.6 |
| 19 | 23.4 | 25.2 | 26.4 | 32.0 | 38.0 | ..... | 64.4 | 68.6 | 70.1 | 71.3 | 71.5 | 71.7 |
| 20 | 23.4 | 25.2 | ..... | 32.2 | 38.4 | 52.8 | 64.6 | 68.7 | 70.1 | 71.3 | 71.5 | 71.8 |
| 21 | 23.4 | 25.2 | 26.5 | 32.3 | ..... | ..... | 64.8 | 68.8 | 70.1 | 71.4 | 71.5 | 71.8 |
| 22 | 23.5 | 25.3 | ..... | ..... | 38.9 | ..... | 65.0 | 68.9 | 70.1 | 71.4 | 71.5 | 71.9 |
| 23 | 23.6 | 25.4 | 26.8 | ..... | ..... | ..... | 65.3 | 69.0 | 70.1 | 71.4 | 71.5 | 72.0 |
| 24 | 23.5 | 25.5 | 27.0 | ..... | 39.5 | ..... | 65.3 | 69.0 | 70.1 | 71.4 | 71.5 | 72.1 |
| 25 | 23.6 | 25.6 | 27.1 | 33.0 | 39.8 | 55.3 | 65.5 | 69.1 | 70.1 | 71.4 | 71.4 | 72.2 |
| 26 | 23.6 | 25.7 | ..... | ..... | 40.0 | 55.7 | 65.7 | 69.2 | 70.2 | 71.4 | 71.4 | 72.3 |
| 27 | 23.6 | ..... | 27.6 | 33.3 | 40.7 | 56.2 | 65.9 | 69.3 | 70.2 | 71.4 | 71.4 | 72.3 |
| 28 | 23.7 | ..... | 27.7 | ..... | 41.3 | 56.7 | 66.1 | 69.4 | 70.2 | 71.5 | 71.4 | 72.3 |
| 29 | 23.7 | ..... | ..... | 33.6 | 41.5 | 57.3 | 66.2 | 69.4 | 70.2 | 71.5 | 71.3 | 72.4 |
| 30 | 23.8 | ..... | 28.2 | ..... | 41.8 | 57.9 | 66.3 | 69.4 | 70.3 | 71.5 | 71.3 | 72.4 |
| 31 | 23.8 | ..... | ..... | ..... | 42.5 | ..... | 66.5 | 69.4 | ..... | 71.5 | ..... | 72.5 |
| Total monthly rise.. | 1.1 | 1.8 | 2.7 | 5.6 | 8.7 | 15.4 | 8.6 | 2.9 | .9 | 1.2 | —.2 | 1.2 |

# THE GREAT BASIN DRAINAGE.

## GENERAL FEATURES.

The Great Basin drainage in California is comprised within the subdrainages Sierra Nevada and Minor Great Basin. Within the Sierra Nevada drainage is a limited area of arid country lying on the eastern slope of the Sierra Nevada. This area includes the Susan and Owens River drainage basins. Within the Minor Great Basin drainage lies the Mohave River drainage basin. Having no outlet to the sea, the entire drainage of these basins is lost mainly through evaporation from the lakes and sinks in which the waters of these rivers collect.

## OWENS RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Owens River has its source in the Sierra Nevada in eastern California and flows southeast parallel with this range, finally discharging its waters into Owens Lake. This basin has a length from north to south of approximately 150 miles with a width of from 20 to 25 miles. It lies between the Sierra Nevada on the west and the White

Mountains on the east. Practically the entire flow of this river is derived from the Sierra Nevada, as it drains the entire eastern slope of this range from Mount Lyell on the north to a point some distance below Mount Whitney on the south. The White Mountains furnish no water for this stream except in times of exceptionally heavy rain storms, which seldom occur on this range. There are numerous tributaries entering Owens River from the west which have their source in the high elevations of the Sierra Nevada, extending from the northern to the southern limits of this basin. The topography of the portion of the Sierra Nevada drained by this stream is extremely rough and precipitous, the mountains rising abruptly from Owens Valley to elevations of 13,000 to 14,000 feet. The formation is of granite, with very little soil covering and sparse timber growth. Numerous lakes and marshes are found in the upper reaches of this portion of the drainage basin.

Owens River, a short distance below its source, enters a flat, swampy country known as Long Valley, where a considerable quantity of its flow is used for the irrigation of meadow lands for stock raising. This water returns to the river channel at the lower end of this valley, at which point the stream enters a deep, narrow gorge with heavy grade. As the river breaks from this canyon it enters Owens Valley, through which it flows for a distance of about 80 miles, finally discharging into Owens Lake. The gaging station at Round Valley is located at the lower end of this canyon. Below this point numerous diversions are made for the irrigation of land in Owens Valley, where the soil is extensively cultivated and large areas are used for the raising of hay and grain. This country is particularly adapted to stock raising, which is carried on extensively throughout the valley. Numerous opportunities for the construction of storage reservoirs occur, both on the main stream and also on the upper reaches of its tributaries, although none have been taken advantage of as yet. The precipitation is extremely light except on the high elevations of the Sierra Nevada, where there is a heavy fall of snow. The melting of this in the spring and summer months feeds the numerous tributaries of this river, insuring a continued flow throughout the year.

### OWENS RIVER NEAR ROUND VALLEY, CAL.

This station was established August 3, 1903, by J. C. Clausen. It is located at the footbridge, 700 feet above the junction of Owens River and Rock Creek. The conditions at this station and the bench marks[a] are described in Water-Supply Paper No. 177, page 50, where are given also references to publications that contain data for previous years.

[a] The elevation of the bench mark is 8.05 feet above the datum of the gage.

*Discharge measurements of Owens River near Round Valley, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 8 | F. R. S. Buttemer | 34 | 73 | 1.75 | 161 |
| January 14 | do | 34 | 77 | 1.92 | 196 |
| January 14 | do | 34 | 79 | 1.93 | 191 |
| August 23 | Hawley and Shuey | 34 | 111 | 2.85 | 465 |
| November 3 | G. R. Shuey | 34 | 85 | 2.14 | 261 |
| November 30 | do | 34 | 79 | 2.00 | 214 |

*Daily gage height, in feet, of Owens River near Round Valley, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.8 | 1.85 | 1.95 | 2.45 | 2.25 | 2.4 | 3.5 | 3.5 | 2.6 | 2.3 | 2.15 | 2.0 |
| 2 | 1.8 | 1.9 | 1.95 | 2.4 | 2.3 | 2.45 | 3.55 | 3.5 | 2.6 | 2.3 | 2.15 | 2.0 |
| 3 | 1.8 | 1.9 | 1.95 | 2.4 | 2.35 | 2.4 | 3.5 | 3.45 | 2.6 | 2.3 | 2.15 | 2.05 |
| 4 | 1.8 | 1.9 | 1.95 | 2.4 | 2.3 | 2.45 | 3.45 | 3.55 | 2.6 | 2.35 | 2.15 | 2.1 |
| 5 | 1.8 | 1.9 | 1.95 | 2.25 | 2.3 | 2.5 | (a) | 3.4 | 2.6 | 2.35 | 2.15 | 2.1 |
| 6 | 1.8 | 1.9 | 1.95 | 2.1 | 2.25 | 2.6 | ..... | 3.3 | 2.55 | 2.35 | 2.15 | 2.1 |
| 7 | 1.75 | 1.9 | 2.0 | 2.15 | 2.2 | 2.7 | ..... | 3.3 | 2.5 | 2.3 | 2.15 | 2.1 |
| 8 | 1.75 | 1.9 | 2.0 | 2.3 | 2.25 | 2.9 | ..... | 3.3 | 2.5 | 2.3 | 2.1 | 2.1 |
| 9 | 1.75 | 1.95 | 2.0 | 2.5 | 2.2 | 3.9 | ..... | 3.25 | 2.45 | 2.3 | 2.1 | 2.15 |
| 10 | 1.75 | 1.95 | 2.0 | 2.6 | 2.25 | 3.95 | ..... | 3.25 | 2.45 | 2.3 | 2.1 | 2.15 |
| 11 | 1.8 | 1.95 | 2.1 | 2.7 | 2.35 | 3.0 | ..... | 3.2 | 2.45 | 2.25 | 2.1 | 2.2 |
| 12 | 1.8 | 1.95 | 2.3 | 2.7 | 2.5 | 3.25 | ..... | 3.1 | 2.45 | 2.2 | 2.1 | 2.2 |
| 13 | 1.9 | 1.95 | 2.25 | 2.75 | 2.45 | 3.3 | ..... | 3.1 | 2.45 | 2.2 | 2.1 | 2.2 |
| 14 | 1.9 | 1.95 | 2.2 | 2.7 | 2.4 | 3.4 | ..... | 3.1 | 2.4 | 2.2 | 2.1 | 2.2 |
| 15 | 1.9 | 1.95 | 2.2 | 2.65 | 2.4 | 3.4 | ..... | 3.05 | 2.4 | 2.2 | 2.05 | 2.2 |
| 16 | 1.9 | 1.95 | 2.25 | 2.7 | 2.4 | 3.45 | ..... | 3.0 | 2.4 | 2.2 | 2.05 | 2.2 |
| 17 | 1.95 | 1.95 | 2.25 | 2.7 | 2.4 | 3.45 | ..... | 2.95 | 2.4 | 2.2 | 2.0 | 2.2 |
| 18 | 2.15 | 1.95 | 2.25 | 2.7 | 2.45 | 3.5 | ..... | 2.95 | 2.4 | 2.2 | 2.0 | 2.2 |
| 19 | 2.1 | 1.95 | 2.3 | 2.7 | 2.6 | 3.55 | ..... | 3.1 | 2.35 | 2.2 | 2.0 | 2.15 |
| 20 | 2.0 | 1.95 | 2.3 | 2.7 | 2.65 | 3.6 | ..... | 3.2 | 2.35 | 2.15 | 2.0 | 2.15 |
| 21 | 2.0 | 2.0 | 2.35 | 2.6 | 2.6 | 3.7 | ..... | 3.2 | 2.3 | 2.15 | 2.0 | 2.1 |
| 22 | 2.1 | 2.0 | 2.35 | 2.6 | 2.55 | 3.75 | ..... | 3.1 | 2.3 | 2.15 | 2.0 | 2.1 |
| 23 | 2.1 | 2.0 | 2.35 | 2.5 | 2.5 | 3.85 | ..... | 2.85 | 2.25 | 2.1 | 2.0 | 2.15 |
| 24 | 2.1 | 2.0 | 2.4 | 2.35 | 2.5 | 3.9 | ..... | 2.85 | 2.25 | 2.1 | 2.0 | 2.15 |
| 25 | 2.1 | 2.0 | 2.35 | 2.25 | 2.5 | 3.9 | ..... | 2.85 | 2.25 | 2.1 | 2.05 | 2.15 |
| 26 | 2.05 | 2.0 | 2.4 | 2.2 | 2.5 | 3.9 | ..... | 2.7 | 2.3 | 2.1 | 2.1 | 2.15 |
| 27 | 2.0 | 1.95 | 2.35 | 2.15 | 2.5 | 3.7 | ..... | 2.6 | 2.3 | 2.1 | 2.1 | 2.2 |
| 28 | 2.0 | 1.95 | 2.3 | 2.15 | 2.45 | 3.65 | ..... | 2.6 | 2.3 | 2.1 | 2.1 | 2.2 |
| 29 | 1.95 | ..... | 2.3 | 2.2 | 2.4 | 3.5 | 3.65 | 2.6 | 2.3 | 2.1 | 2.1 | 2.2 |
| 30 | 1.9 | ..... | 2.35 | 2.2 | 2.45 | 3.6 | 3.6 | 2.6 | 2.3 | 2.15 | 2.1 | 2.2 |
| 31 | 1.9 | ..... | 2.5 | ..... | 2.4 | ..... | 3.6 | 2.6 | ..... | 2.15 | ..... | 2.2 |

(a) Station discontinued; operations resumed July 29.

*Rating table for Owens River near Round Valley, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.60 | 132 | 2.10 | 244 | 2.60 | 385 | 3.10 | 545 | 3.60 | 715 |
| 1.70 | 152 | 2.20 | 270 | 2.70 | 416 | 3.20 | 578 | 3.70 | 750 |
| 1.80 | 172 | 2.30 | 297 | 2.80 | 448 | 3.30 | 612 | 3.80 | 785 |
| 1.90 | 194 | 2.40 | 326 | 2.90 | 480 | 3.40 | 646 | 3.90 | 821 |
| 2.00 | 218 | 2.50 | 355 | 3.00 | 512 | 3.50 | 680 | | |

NOTE.—This table is based on discharge measurements made during 1903–6 and is well defined between gage heights 1.7 feet and 2.8 feet.

*Monthly discharge of Owens River near Round Valley, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 257 | 162 | 199 | 12,200 |
| February | 218 | 185 | 205 | 11,400 |
| March | 355 | 206 | 270 | 16,600 |
| April | 432 | 244 | 345 | 20,500 |
| May | 400 | 270 | 328 | 20,200 |
| June | 839 | 326 | 624 | 37,100 |
| July[a] | 732 | 663 | 696 | 42,800 |
| August | 680 | 385 | 535 | 32,900 |
| September | 385 | 284 | 330 | 19,600 |
| October | 312 | 244 | 273 | 16,800 |
| November | 257 | 218 | 239 | 14,200 |
| December | 270 | 218 | 256 | 15,700 |
| The year | 839 | 162 | 358 | 260,000 |

[a] Discharge interpolated July 5 to 28.

NOTE.—Values are rated as follows: June and July, good; remainder of 1905, excellent.

## OWENS RIVER NEAR TINEMAHA, CAL.

This station was established September 20, 1906, but measurements were made prior to this date by the city of Los Angeles, Cal. It is located about 7 miles south of Tinemaha at a basaltic knoll in the floor of the valley known as "Charlies Butte." It was described in Water-Supply Paper No. 177 as near Independence.

The channel is straight for 300 feet above and 200 feet below the station. The right bank is high and rocky with a growth of willows along the bank; the left is low and liable to overflow at high stages of the river. The channel has a carrying capacity of about 1,800 second-feet before it overflows. The bed of the stream is composed of sand and gravel and is subject to some change between high and low stages of the river.

Discharge measurements are made from a cable and car. The initial point for soundings is a spike in post on right bank.

The gage, which is read by Ray Bowers, is a vertical rod fastened to a post on left bank of the stream The bench mark is a nail in the south side of the post that supports the cable on the left bank; elevation, 8.36 feet above the zero of the gage.

During high water this station is inaccessible, and measurements are made at the county bridge near Citrus, about 12 miles below. The conditions at this station are described in Water-Supply Paper No. 177, p. 74, where are given, also, references to publications that contain data for previous years.

*Discharge measurements of Owens River near Tinemaha, Cal., by G. R. Shuey, in 1906.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| January 3 | 1.60 | 284 | April 12 | 2.72 | 506 |
| January 10 | 1.80 | 319 | April 25 | ..... | 262 |
| January 18 | 2.65 | 467 | May 3 | 1.10 | 186 |
| January 24 | ..... | 555 | May 8 | .90 | 162 |
| February 6 | 2.11 | 377 | May 24 | 1.16 | 201 |
| February 14 | 2.04 | 347 | June 5 | 1.30 | 224 |
| February 21 | 1.93 | 350 | June 18 | 3.93 | 786 |
| February 26 | 1.80 | 314 | October 8 | 1.40 | 293 |
| March 8 | 1.70 | 277 | October 18 | 1.57 | 360 |
| March 20 | 2.92 | 523 | November 1 | 1.80 | 418 |
| March 27 | 2.67 | 478 | December 8 | 2.62 | 532 |
| April 6 | 2.37 | 462 | December 17 | 2.60 | 515 |

*Daily gage height, in feet, of Owens River near Tinemaha, Cal., for 1906.*

| Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 1.45 | 1.80 | 2.15 | 17 | ..... | 1.55 | 2.05 | 2.60 |
| 2 | ..... | 1.52 | 1.85 | 2.20 | 18 | ..... | 1.57 | 2.05 | 2.55 |
| 3 | ..... | 1.45 | 1.90 | 2.30 | 19 | ..... | 1.58 | 2.05 | 2.50 |
| 4 | ..... | 1.40 | 1.90 | 2.45 | 20 | 1.85 | 1.60 | 2.00 | 2.45 |
| 5 | ..... | 1.40 | 1.95 | 2.60 | 21 | 1.82 | 1.55 | 2.00 | 2.40 |
| 6 | ..... | 1.38 | 2.00 | 2.70 | 22 | 1.80 | 1.57 | 2.00 | 2.35 |
| 7 | ..... | 1.40 | 2.00 | 2.65 | 23 | 1.75 | 1.60 | 2.00 | 2.35 |
| 8 | ..... | 1.40 | 2.05 | 2.60 | 24 | 1.72 | 1.70 | 2.00 | 2.40 |
| 9 | ..... | 1.38 | 2.05 | 2.55 | 25 | 1.60 | 1.82 | 2.10 | 2.45 |
| 10 | ..... | 1.36 | 2.05 | 2.50 | 26 | 1.50 | 1.85 | 2.05 | 2.50 |
| 11 | ..... | 1.35 | 2.00 | 2.45 | 27 | 1.45 | 1.87 | 2.10 | 2.55 |
| 12 | ..... | 1.35 | 2.00 | 2.50 | 28 | 1.40 | 1.85 | 2.20 | 2.60 |
| 13 | ..... | 1.30 | 2.00 | 2.70 | 29 | 1.35 | 1.90 | 2.30 | 2.65 |
| 14 | ..... | 1.35 | 2.00 | 2.80 | 30 | 1.38 | 1.80 | 2.20 | 2.70 |
| 15 | ..... | 1.38 | 2.05 | 2.70 | 31 | ..... | 1.80 | ..... | 2.75 |
| 16 | ..... | 1.45 | 2.10 | 2.70 | | | | | |

*Rating table for Owens River near Tinemaha, Cal., from October 19, 1906, to December 31, 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.00 | 278 | 1.50 | 342 | 1.90 | 402 | 2.30 | 470 | 2.70 | 542 |
| 1.10 | 290 | 1.60 | 357 | 2.00 | 418 | 2.40 | 488 | 2.80 | 560 |
| 1.20 | 302 | 1.70 | 372 | 2.10 | 434 | 2.50 | 506 | 2.90 | 580 |
| 1.30 | 314 | 1.80 | 387 | 2.20 | 452 | 2.60 | 524 | 3.00 | 600 |
| 1.40 | 327 | | | | | | | | |

NOTE.—This table is based on 5 discharge measurements made during 1906 and is fairly well defined.

*Discharge measurements of Owens River near Citrus, Cal., by Buttemer and Shuey in 1906.*

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Sec.-ft.* | | *Sec.-ft.* |
| January 3 | 283 | July 13 | 2,210 |
| January 19 | 440 | July 21 | 2,460 |
| January 21 | 595 | July 29 | 2,610 |
| June 4 | 214 | August 9 | 1,160 |
| June 16 | 586 | August 17 | 1,160 |
| June 26 | 1,370 | September 10 | 432 |
| July 1 | 1,520 | October 7 | 321 |
| July 8 | 2,080 | | |

*Monthly discharge of Owens River near Tinemaha, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 635 | 270 | 436 | 26,800 |
| February | 443 | 308 | 358 | 19,990 |
| March | 680 | 277 | 438 | 26,900 |
| April | 530 | 213 | 388 | 23,100 |
| May | 285 | 162 | 200 | 12,300 |
| June | 1,540 | 224 | 729 | 43,400 |
| July | 2,610 | 1,520 | 2,230 | 137,000 |
| August | 2,220 | 730 | 1,210 | 74,400 |
| September | 700 | 352 | 448 | 26,700 |
| October | 401 | 270 | 339 | 20,800 |
| November | 470 | 387 | 423 | 25,200 |
| December | 560 | 443 | 510 | 31,400 |
| The year | 2,610 | 162 | 642 | 468,000 |

NOTE.—From January 1 to June 30 the daily discharge was interpolated between measurements at the regular station. During July, August, and September the regular station was inaccessible on account of floods and the daily discharge has been interpolated between measurements made at Citrus. The values for these months are probably too small, as the Eastside and Stevens canals divert water above. After September the discharge was obtained from the rating table. Values for the year are approximate.

## ROCK CREEK NEAR ROUND VALLEY, CAL.

This station was established August 3, 1903, by J. C. Clausen. It is located at the wagon bridge on the road from Long Valley to Bishop, 3,500 feet above the mouth of the creek. The conditions and the bench marks are described in Water Supply Paper No. 177, page 52, where are given also references to publications that contain data for previous years.

*Discharge measurements of Rock Creek near Round Valley, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 8 | F. R. S. Buttemer | 13.5 | 17 | 1.58 | 23 |
| January 14 | do | 14.6 | 21 | 1.93 | 41 |
| August 27 | R. S. Hawley | 14 | 21 | 1.75 | 51 |
| November 3 | G. R. Shuey | 13 | 16 | 1.55 | 37 |
| November 30 | do | 13 | 19 | 1.70 | 47 |

*Daily gage height, in feet, of Rock Creek near Round Valley, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.5 | 1.55 | 1.35 | 1.5 | 1.2 | 1.8 | 3.15 | 2.75 | 1.9 | 1.55 | 1.6 | 1.7 |
| 2 | 1.45 | 1.55 | 1.35 | 1.5 | 1.2 | 1.75 | 3.25 | 2.75 | 1.9 | 1.55 | 1.6 | 1.7 |
| 3 | 1.5 | 1.55 | 1.35 | 1.55 | 1.2 | 1.8 | 3.2 | 2.75 | 1.9 | 1.55 | 1.6 | 1.75 |
| 4 | 1.5 | 1.5 | 1.35 | 1.5 | 1.25 | 1.8 | 3.2 | 2.75 | 1.95 | 1.55 | 1.6 | 1.75 |
| 5 | 1.6 | 1.5 | 1.35 | 1.5 | 1.25 | 1.8 | (a) | 2.7 | 1.9 | 1.55 | 1.65 | 1.8 |
| 6 | 1.7 | 1.45 | 1.35 | 1.45 | 1.25 | 1.85 | ..... | 2.7 | 1.9 | 1.55 | 1.65 | 1.8 |
| 7 | 1.65 | 1.4 | 1.3 | 1.5 | 1.3 | 1.9 | ..... | 2.65 | 1.85 | 1.55 | 1.65 | 1.8 |
| 8 | 1.6 | 1.4 | 1.3 | 1.4 | 1.3 | 2.15 | ..... | 2.6 | 1.8 | 1.55 | 1.65 | 1.8 |
| 9 | 1.6 | 1.45 | 1.3 | 1.3 | 1.3 | 2.35 | ..... | 2.6 | 1.75 | 1.55 | 1.65 | 1.8 |
| 10 | 1.65 | 1.45 | 1.35 | 1.3 | 1.35 | 2.5 | ..... | 2.65 | 1.75 | 1.55 | 1.65 | 1.75 |
| 11 | 1.75 | 1.45 | 1.4 | 1.4 | 1.45 | 2.8 | ..... | 2.7 | 1.75 | 1.5 | 1.65 | 1.7 |
| 12 | 1.8 | 1.45 | 1.8 | 1.4 | 1.75 | 2.95 | ..... | 2.65 | 1.75 | 1.5 | 1.65 | 1.65 |
| 13 | 1.9 | 1.45 | 2.0 | 1.45 | 1.8 | 3.2 | ..... | 2.7 | 1.75 | 1.5 | 1.65 | 1.6 |
| 14 | 1.9 | 1.45 | 2.2 | 1.4 | 1.95 | 3.35 | ..... | 2.7 | 1.7 | 1.55 | 1.65 | 1.55 |
| 15 | 2.0 | 1.4 | 2.4 | 1.3 | 1.95 | 3.4 | ..... | 2.65 | 1.7 | 1.55 | 1.65 | 1.5 |

(a) Station discontinued; operations resumed July 29.

*Daily gage height, in feet, of Rock Creek near Round Valley, Cal., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 2.1 | 1.4 | 2.3 | 1.3 | 1.9 | 3.4 | ..... | 2.6 | 1.7 | 1.55 | 1.65 | 1.5 |
| 17 | 2.1 | 1.4 | 2.2 | 1.3 | 1.9 | 3.4 | ..... | 2.55 | 1.7 | 1.55 | 1.65 | 1.55 |
| 18 | 2.1 | 1.4 | 2.2 | 1.25 | 2.2 | 3.45 | ..... | 2.55 | 1.7 | 1.55 | 1.65 | 1.6 |
| 19 | 4.2 | 1.4 | 2.1 | 1.25 | 2.3 | 3.5 | ..... | 2.6 | 1.65 | 1.55 | 1.65 | 1.6 |
| 20 | 1.4 | 1.4 | 2.1 | 1.2 | 2.4 | 3.5 | ..... | 2.65 | 1.65 | 1.6 | 1.65 | 1.6 |
| 21 | 1.5 | 1.4 | 1.95 | 1.2 | 2.4 | 3.55 | ..... | 2.6 | 1.6 | 1.6 | 1.6 | 1.6 |
| 22 | 1.6 | 1.4 | 1.8 | 1.2 | 2.3 | 3.6 | ..... | 2.5 | 1.55 | 1.6 | 1.5 | 1.6 |
| 23 | 1.7 | 1.4 | 1.7 | 1.2 | 2.3 | 3.7 | ..... | 2.45 | 1.5 | 1.55 | 1.45 | 1.6 |
| 24 | 1.7 | 1.4 | 1.6 | 1.2 | 2.25 | 3.7 | ..... | 2.45 | 1.5 | 1.5 | 1.45 | 1.6 |
| 25 | 1.6 | 1.35 | 1.55 | 1.15 | 2.1 | 3.8 | ..... | 2.45 | 1.5 | 1.5 | 1.5 | 1.6 |
| 26 | 1.55 | 1.35 | 1.6 | 1.15 | 2.15 | 3.8 | ..... | 2.0 | 1.55 | 1.45 | 1.6 | 1.6 |
| 27 | 1.5 | 1.35 | 1.5 | 1.15 | 2.0 | 3.6 | ..... | 2.0 | 1.55 | 1.45 | 1.7 | 1.6 |
| 28 | 1.5 | 1.35 | 1.4 | 1.15 | 1.85 | 3.55 | ..... | 1.95 | 1.6 | 1.45 | 1.75 | 1.6 |
| 29 | 1.55 | ..... | 1.4 | 1.2 | 1.8 | 3.4 | 2.85 | 1.9 | 1.6 | 1.45 | 1.8 | 1.6 |
| 30 | 1.55 | ..... | 1.4 | 1.2 | 1.8 | 3.5 | 2.85 | 1.9 | 1.55 | 1.5 | 1.8 | 1.6 |
| 31 | 1.55 | ..... | 1.5 | ..... | 1.8 | ..... | 2.8 | 1.9 | ..... | 1.55 | ..... | 1.6 |

*Rating table for Rock Creek near Round Valley, Cal., from January 20, 1906, to December 31, 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.00 | 12 | 1.60 | 40 | 2.20 | 83 | 2.80 | 131 | 3.40 | 179 |
| 1.10 | 15 | 1.70 | 47 | 2.30 | 91 | 2.90 | 139 | 3.50 | 188 |
| 1.20 | 19 | 1.80 | 54 | 2.40 | 99 | 3.00 | 147 | 3.60 | 197 |
| 1.30 | 23 | 1.90 | 61 | 2.50 | 107 | 3.10 | 155 | 3.70 | 206 |
| 1.40 | 28 | 2.00 | 68 | 2.60 | 115 | 3.20 | 163 | 3.80 | 215 |
| 1.50 | 34 | 2.10 | 75 | 2.70 | 123 | 3.30 | 171 | | |

NOTE.—This table is based on 3 discharge measurements made during 1906 and is not well defined. The table used January 1 to 19 gives a much smaller discharge at the same gage height.

*Monthly discharge of Rock Creek near Round Valley, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 200 | 17 | 38.8 | 2,390 |
| February | 37 | 25 | 29.7 | 1,650 |
| March | 99 | 23 | 45.7 | 2,810 |
| April | 37 | 17 | 24.6 | 1,460 |
| May | 99 | 19 | 54.2 | 3,330 |
| June | 215 | 50 | 145 | 8,630 |
| July | 167 | 131 | [a] 150 | 9,220 |
| August | 127 | 61 | 107 | 6,580 |
| September | 64 | 34 | 47.4 | 2,820 |
| October | 40 | 31 | 35.9 | 2,210 |
| November | 54 | 31 | 42.6 | 2,530 |
| December | 54 | 34 | 43.5 | 2,680 |
| The year | 215 | 17 | 63.7 | 46,300 |

[a] Mean for seven days taken as mean for the month.

NOTE.—These values are fair.

## PINE CREEK NEAR ROUND VALLEY, CAL.

This station was established August 3, 1903, by J. C. Clausen. It is located 150 feet below the wagon bridge on the road from Bishop to Long Valley and 100 feet above the mouth of the creek. The conditions and the bench marks are described in Water-Supply Paper

No. 177, page 55, where are given also references to publications that contain data for previous years.

On June 15, 1906, the gage was washed out. On August 23 a new gage was placed at the wagon bridge on the Long Valley road about 150 feet above the old gage. It consists of a $\frac{1}{4}$ by $1\frac{1}{2}$ inch steel rod fastened to the downstream side of the bridge, near the right bank, and is graduated to 0.05 of a foot. No reference was made to any bench mark.

This section at the bridge is very rough and rocky, but not subject to much change. During very high stages gagings can be made from the bridge, while at ordinary stages a wading section below the bridge is more satisfactory.

*Discharge measurements of Pine Creek near Round Valley, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 8 | F. R. S. Buttemer | 19 | 18 | 1.80 | 7.0 |
| January 14 | do | 20 | 25 | 2.13 | 22 |
| August 23 | Shuey and Hawley | 12 | 33 | 3.85 | 90 |
| August 27 | R. S. Hawley | 24 | 26 | 3.75 | 92 |
| November 3 | G. R. Shuey | 12 | 22 | 2.95 | 9.0 |
| November 30 | do | 12 | 21 | 3.00 | 9.2 |

*Daily gage height, in feet, of Pine Creek River near Round Valley, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.8 | 1.85 | 1.8 | 1.85 | 1.8 | 2.05 | ..... | 3.65 | 3.25 | 3.0 | 3.0 |
| 2 | 1.8 | 1.85 | 1.8 | 1.8 | 1.8 | 2.0 | ..... | 3.65 | 3.25 | 3.0 | 3.0 |
| 3 | 1.8 | 1.85 | 1.8 | 1.8 | 1.8 | 2.0 | ..... | 3.6 | 3.25 | 3.0 | 3.0 |
| 4 | 1.8 | 1.85 | 1.8 | 1.8 | 1.85 | 2.0 | ..... | 3.6 | 3.25 | 3.0 | 3.0 |
| 5 | 1.8 | 1.8 | 1.8 | 1.8 | 1.85 | 2.2 | ..... | 3.6 | 3.25 | 3.0 | 3.0 |
| 6 | 1.8 | 1.8 | 1.8 | 1.9 | 1.8 | 2.4 | ..... | 3.6 | 3.2 | 3.0 | 3.0 |
| 7 | 1.8 | 1.8 | 1.75 | 1.9 | 1.8 | 2.55 | ..... | 3.6 | 3.2 | 3.0 | 3.0 |
| 8 | 1.8 | 1.8 | 1.75 | 1.8 | 1.8 | 2.6 | ..... | 3.6 | 3.15 | 2.9 | 3.0 |
| 9 | 1.8 | 1.8 | 1.75 | 1.85 | 1.8 | 2.75 | ..... | 3.6 | 3.15 | 2.9 | 3.0 |
| 10 | 1.85 | 1.8 | 1.75 | 1.8 | 1.8 | 2.9 | ..... | 3.6 | 3.15 | 2.9 | 3.0 |
| 11 | 1.9 | 1.8 | 1.8 | 1.8 | 1.85 | 3.2 | ..... | 3.55 | 3.1 | 2.9 | 2.95 |
| 12 | 1.9 | 1.85 | 2.0 | 1.85 | 1.85 | 3.25 | ..... | 3.55 | 3.05 | 2.9 | 2.95 |
| 13 | 2.0 | 1.85 | 2.1 | 1.8 | 1.85 | 3.45 | ..... | 3.5 | 3.05 | 2.9 | 2.9 |
| 14 | 2.25 | 1.85 | 2.2 | 1.8 | 1.85 | 3.5 | ..... | 3.45 | 3.05 | 2.9 | 2.9 |
| 15 | 2.25 | 1.85 | 2.3 | 1.85 | 1.85 | ..... | ..... | 3.4 | 3.05 | 2.9 | 2.9 |
| 16 | 2.25 | 1.85 | 2.2 | 1.85 | 1.85 | ..... | ..... | 3.4 | 3.05 | 2.9 | 2.9 |
| 17 | 2.15 | 1.8 | 2.1 | 1.8 | 1.9 | ..... | ..... | 3.35 | 3.0 | 2.9 | 2.9 |
| 18 | 2.1 | 1.8 | 2.1 | 1.8 | 1.95 | ..... | ..... | 3.35 | 3.0 | 2.9 | 2.9 |
| 19 | 2.0 | 1.8 | 2.1 | 1.8 | 2.2 | ..... | ..... | 3.35 | 3.0 | 2.9 | 2.9 |
| 20 | 1.95 | 1.8 | 2.1 | 1.8 | 2.1 | ..... | ..... | 3.35 | 3.0 | 2.9 | 2.95 |
| 21 | 1.95 | 1.8 | 2.0 | 1.8 | 1.85 | ..... | ..... | 3.3 | 3.0 | 2.9 | 2.95 |
| 22 | 1.95 | 1.8 | 1.95 | 1.8 | 1.85 | ..... | ..... | 3.25 | 3.0 | 2.95 | 2.95 |
| 23 | 1.9 | 1.8 | 1.95 | 1.8 | 2.15 | ..... | 3.85 | 3.25 | 3.0 | 3.0 | 2.95 |
| 24 | 1.9 | 1.8 | 1.9 | 1.8 | 2.3 | ..... | 3.85 | 3.25 | 3.0 | 3.0 | 2.95 |
| 25 | 1.9 | 1.8 | 2.0 | 1.8 | 2.3 | ..... | 3.8 | 3.25 | 3.0 | 3.0 | 2.95 |
| 26 | 1.85 | 1.8 | 1.95 | 1.8 | 2.3 | ..... | 3.8 | 3.25 | 3.0 | 3.0 | 2.95 |
| 27 | 1.85 | 1.8 | 1.9 | 1.8 | 2.2 | ..... | 3.8 | 3.25 | 3.0 | 3.0 | 2.95 |
| 28 | 1.85 | 1.8 | 1.85 | 1.8 | 2.2 | ..... | 3.8 | 3.25 | 3.0 | 3.0 | 2.95 |
| 29 | 1.85 | ..... | 1.8 | 1.8 | 2.15 | ..... | 3.8 | 3.25 | 3.0 | 3.0 | 2.95 |
| 30 | 1.85 | ..... | 1.8 | 1.85 | 2.15 | ..... | 3.75 | 3.25 | 3.0 | 3.0 | 2.95 |
| 31 | 1.85 | ..... | 1.9 | ..... | 2.1 | ..... | 3.7 | ..... | 3.0 | ..... | 2.95 |

*Rating tables for Pine Creek near Round Valley, Cal.*

JANUARY 1 TO JUNE 14, 1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.70 | 4 | 2.10 | 23 | 2.50 | 45 | 2.90 | 75 | 3.30 | 119 |
| 1.80 | 8 | 2.20 | 28 | 2.60 | 52 | 3.00 | 85 | 3.40 | 133 |
| 1.90 | 13 | 2.30 | 33 | 2.70 | 59 | 3.10 | 95 | 3.50 | 149 |
| 2.00 | 18 | 2.40 | 39 | 2.80 | 67 | 3.20 | 106 | | |

AUGUST 23 TO DECEMBER 31, 1906.[b]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2.90 | 5 | 3.20 | 24 | 3.40 | 42 | 3.60 | 64 | 3.80 | 89 |
| 3.00 | 10 | 3.30 | 33 | 3.50 | 53 | 3.70 | 76 | 3.90 | 103 |
| 3.10 | 16 | | | | | | | | |

[a] This table is based on discharge measurements made during 1903–1906 and is well defined below gage height 3 feet.
[b] This table is based on 4 discharge measurements made during 1906 and is not well defined

*Monthly discharge of Pine Creek near Round Valley, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 30 | 8 | 13.7 | 842 |
| February | 10 | 8 | 8.6 | 478 |
| March | 33 | 6 | 14.5 | 892 |
| April | 13 | 8 | 8.7 | 518 |
| May | 33 | 8 | 16.0 | 984 |
| June | | | 130 | 7,740 |
| July | | | 160 | 9,840 |
| August | | | 105 | 6,460 |
| September | 70 | 28 | 46.2 | 2,750 |
| October | 28 | 10 | 15.5 | 953 |
| November | 10 | 5 | 7.6 | 452 |
| December | 10 | 5 | 7.5 | 461 |
| The year | | 5 | 44.4 | 32,400 |

NOTE.—Monthly means for June, July, and August estimated, and are only approximate; values for remainder of 1906 fair.

## BISHOP CREEK NEAR BISHOP, CAL.

This station was established August 10, 1903, at the wagon bridge on the Bishop road, about 4¼ miles from Bishop and about 2 miles from the point where the creek leaves the canyon. The conditions and the bench marks are described in Water-Supply Paper No. 177, page 62, where are given also references to publications that contain data for previous years.

*Discharge measurements of Bishop Creek near Bishop, Cal., for 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 1[a] | F. R. S. Buttemer | 16 | 28 | 1.95 | 20 |
| January 16 | do | 16 | 24 | 1.76 | 32 |
| January 24 | do | 16 | 27 | 1.83 | 38 |
| August 24 | Shuey and Hawley | 16 | 41 | 3.10 | 241 |
| November 5 | G. R. Shuey | 16 | 24 | 1.71 | 35 |
| December 3 | do | 16 | 26 | 1.90 | 52 |

[a] Channel obstructed by rocks at time of measurement.

*Daily gage height, in feet, of Bishop Creek near Bishop, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.95 | 1.6 | 1.6 | 1.8 | 2.5 | 2.45 | 4.75 | 4.0 | 2.8 | 2.2 | 1.5 | 1.85 |
| 2 | 1.85 | 1.65 | 1.65 | 1.7 | 2.4 | 2.4 | 4.9 | 3.9 | 2.75 | 2.2 | 1.45 | 1.85 |
| 3 | 1.85 | 1.6 | 1.6 | 1.8 | 2.45 | 2.45 | 5.2 | 3.8 | 2.7 | 2.15 | 1.35 | 1.9 |
| 4 | 1.6 | 1.65 | 1.65 | 1.8 | 2.5 | 2.5 | 5.5 | 3.7 | 2.7 | 2.2 | 1.4 | 1.95 |
| 5 | 1.6 | 1.6 | 1.6 | 1.8 | 2.55 | 2.55 | 5.3 | 3.75 | 2.65 | 2.2 | 1.4 | 1.95 |
| 6 | 1.6 | 1.65 | 1.65 | 1.9 | 2.6 | 2.5 | 5.6 | 3.75 | 2.6 | 2.1 | 1.45 | 1.9 |
| 7 | 1.5 | 1.6 | 1.65 | 1.95 | 2.65 | 2.6 | (a) | 3.8 | 2.65 | 2.15 | 1.45 | 1.85 |
| 8 | 1.5 | 1.6 | 1.7 | 1.9 | 2.75 | 2.75 | ..... | 3.7 | 2.65 | 2.2 | 1.4 | 1.9 |
| 9 | 1.5 | 1.6 | 1.7 | 1.9 | 2.9 | 2.9 | ..... | 3.65 | 2.6 | 2.1 | 1.45 | 1.85 |
| 10 | 1.55 | 1.55 | 1.7 | 1.9 | 2.95 | 3.7 | ..... | 3.75 | 2.65 | 2.0 | 1.4 | 1.9 |
| 11 | 1.65 | 1.6 | 1.7 | 1.75 | 2.85 | 3.9 | ..... | 3.8 | 2.6 | 2.0 | 1.5 | 2.0 |
| 12 | 1.6 | 1.55 | 1.8 | 1.75 | 2.75 | 3.75 | ..... | 3.7 | 2.6 | 1.95 | 1.65 | 1.95 |
| 13 | 1.5 | 1.6 | 1.5 | 1.7 | 2.9 | 3.65 | ..... | 3.65 | 2.5 | 1.9 | 1.65 | 2.0 |
| 14 | 1.5 | 1.6 | 2.0 | 1.6 | 2.85 | 3.6 | ..... | 3.65 | 2.5 | 1.9 | 1.7 | 2.0 |
| 15 | 1.75 | 1.6 | 2.0 | 1.7 | 2.8 | 3.7 | 5.45 | 3.7 | 2.4 | 1.8 | 1.7 | 1.95 |
| 16 | 1.8 | 1.6 | 2.2 | 1.8 | 2.8 | 3.85 | 5.4 | 3.7 | 2.45 | 1.75 | 1.65 | 2.0 |
| 17 | 1.9 | 1.6 | 2.2 | 1.8 | 2.85 | 3.8 | 5.5 | 3.75 | 2.4 | 1.75 | 1.65 | 1.95 |
| 18 | 2.0 | 1.6 | 2.2 | 1.85 | 2.9 | 3.9 | 5.4 | 3.7 | 2.4 | 1.7 | 1.65 | 2.0 |
| 19 | 2.1 | 1.6 | 2.1 | 1.85 | 2.95 | 3.9 | 5.3 | 3.7 | 2.35 | 1.7 | 1.7 | 1.9 |
| 20 | 2.1 | 1.6 | 2.1 | 1.9 | 3.0 | 4.2 | 5.1 | 3.65 | 2.4 | 1.75 | 1.65 | 1.95 |
| 21 | 2.3 | 1.65 | 2.0 | 1.95 | 2.95 | 4.5 | 5.0 | 3.6 | 2.3 | 1.75 | 1.65 | 1.9 |
| 22 | 2.15 | 1.7 | 2.0 | 2.0 | 2.8 | 4.7 | 5.0 | 3.7 | 2.25 | 1.75 | 1.6 | 1.95 |
| 23 | 2.0 | 1.6 | 2.0 | 2.0 | 2.85 | 4.75 | 5.3 | 3.65 | 2.2 | 1.75 | 1.6 | 1.9 |
| 24 | 1.9 | 1.65 | 1.9 | 1.9 | 2.75 | 4.8 | 5.0 | 3.65 | 2.3 | 1.8 | 1.65 | 1.9 |
| 25 | 1.85 | 1.85 | 1.9 | 2.0 | 2.8 | 4.9 | 5.4 | 3.6 | 2.2 | 1.75 | 1.65 | 1.9 |
| 26 | 1.8 | 1.6 | 1.95 | 1.95 | 2.75 | 4.95 | 5.1 | 3.55 | 2.2 | 1.7 | 1.7 | 1.95 |
| 27 | 1.7 | 1.65 | 1.9 | 2.55 | 2.7 | 4.5 | 5.1 | 3.4 | 2.2 | 1.7 | 1.85 | 2.0 |
| 28 | 1.75 | 1.65 | 1.9 | 2.55 | 2.65 | 4.35 | 5.3 | 3.35 | 2.25 | 1.65 | 1.8 | 2.0 |
| 29 | 1.65 | ..... | 1.85 | 2.55 | 2.6 | 4.2 | 4.4 | 2.8 | 2.2 | 1.6 | 1.8 | 1.95 |
| 30 | 1.6 | ..... | 1.9 | 2.5 | 2.5 | 4.4 | 4.4 | 2.85 | 2.2 | 1.55 | 1.8 | 1.95 |
| 31 | 1.65 | ..... | 1.85 | ..... | 2.6 | ..... | 4.3 | 2.85 | ..... | 1.55 | ..... | 2.0 |

(a) Station discontinued; operation resumed July 15.

*Rating table for Bishop Creek near Bishop, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.40 | 7 | 2.20 | 84 | 3.00 | 220 | 3.80 | 393 | 4.60 | 582 |
| 1.50 | 10 | 2.30 | 98 | 3.10 | 240 | 3.90 | 416 | 4.70 | 606 |
| 1.60 | 14 | 2.40 | 114 | 3.20 | 261 | 4.00 | 439 | 4.80 | 630 |
| 1.70 | 24 | 2.50 | 130 | 3.30 | 282 | 4.10 | 462 | 4.90 | 654 |
| 1.80 | 35 | 2.60 | 147 | 3.40 | 303 | 4.20 | 486 | 5.00 | 678 |
| 1.90 | 46 | 2.70 | 164 | 3.50 | 325 | 4.30 | 510 | 5.20 | 726 |
| 2.00 | 58 | 2.80 | 182 | 3.60 | 347 | 4.40 | 534 | 5.40 | 774 |
| 2.10 | 70 | 2.90 | 201 | 3.70 | 370 | 4.50 | 558 | 5.60 | 822 |

NOTE.—This table is based on 6 discharge measurements made during 1906, and is not well defined.

*Monthly discharge of Bishop Creek near Bishop, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 98 | 10 | 33.4 | 2,050 |
| February | 40 | 12 | 16.4 | 911 |
| March | 84 | 10 | 42.0 | 2,580 |
| April | 138 | 14 | 52.8 | 3,140 |
| May | 220 | 114 | 172 | 10,600 |
| June | 666 | 114 | 382 | 22,700 |
| July | 822 | 510 | (a) 706 | 43,400 |
| August | 439 | 182 | 350 | 21,500 |
| September | 182 | 84 | 124 | 7,380 |
| October | 84 | 12 | 45.3 | 2,780 |
| November | 40 | 6 | 17.5 | 1,040 |
| December | 58 | 35 | 50.0 | 3,070 |
| The year | 822 | 6 | 166 | 121,000 |

(a) Mean of 23 days taken as the mean for the month.

NOTE.—These values are fair.

### BIG PINE CREEK NEAR BIG PINE, CAL.

This station was established December 5, 1903, by R. S. Hawley. It is located 3 miles southwest of Big Pine, Cal., at a point where the creek leaves the foothills. The conditions and the bench marks are described in Water-Supply Paper No. 177, page 78, where are given also references to publications that contain data for previous years. No gage-height record was kept during 1906.

*Discharge measurements of Big Pine Creek near Big Pine, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 2 | F. R. S. Buttemer | 14 | 14 | 2.25 | 11 |
| January 17 | do | 14 | 14 | 2.32 | 13 |
| January 24 | do | 14 | 10 | 1.98 | 13 |
| August 24 | Hawley and Shuey | 14 | 26 | (a) | 112 |
| November 1 | G. R. Shuey | 8 | 12 | (a) | 24 |
| December 6 | do | 9 | 13 | (a) | 20 |
| December 16 | do | 8 | 13 | (a) | 20 |

a Gage out.

### BIRCH CREEK NEAR TINEMAHA, CAL.

This station, originally established June 14, 1905, was reestablished on December 7, 1906. It is located about 8 miles south of Big Pine and 1 mile west of Fish Springs schoolhouse and about 500 feet west of Peterson's ranch house. The conditions at this station are described in Water-Supply Paper No. 177, page 80. The gage is a vertical staff nailed to a post, and is graduated to feet and tenths. The bench mark is two large spikes driven in the base of a 4-inch birch tree about 50 feet northeast of the rod; elevation, 0.52 feet above the zero of the gage.

*Discharge measurements of Birch Creek near Tinemaha, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 11 | G. R. Shuey | | | 0.52 | 3.1 |
| January 29 | do | | | | 3.1 |
| March 8 | do | | | | 3.2 |
| December 7 | do | 5 | 4.2 | a.35 | 6.0 |

a By new gage.

*Daily gage height, in feet, of Birch Creek near Tinemaha, Cal., for 1906.*

| Day. | Dec. | Day. | Dec. | Day. | Dec. | Day. | Dec. |
|---|---|---|---|---|---|---|---|
| 7 | 0.35 | 14 | 0.4 | 21 | 0.3 | 28 | 0.4 |
| 8 | .35 | 15 | .35 | 22 | .3 | 29 | .35 |
| 9 | .3 | 16 | .3 | 23 | .3 | 30 | .35 |
| 10 | .4 | 17 | .3 | 24 | .3 | 31 | .35 |
| 11 | .4 | 18 | .3 | 25 | .35 | | |
| 12 | .4 | 19 | .3 | 26 | .45 | | |
| 13 | .4 | 20 | .3 | 27 | .4 | | |

### TINEMAHA CREEK NEAR TINEMAHA, CAL.

Tinemaha Creek is tributary to Owens River from the eastern slope of the Sierra Nevada.

The station was established December 7, 1906. It is located about 500 feet south of the Peterson ranch house, about 8 miles south of Big Pine, and about 1 mile west of Fish Springs schoolhouse.

The channel is straight for about 40 feet above and for 30 feet below the measuring section, and the velocity is moderate at ordinary stages. Both banks are steep, about 5 or 6 feet high, and covered with a scrubby growth. The bottom is composed of clean gravel and is not likely to shift. There is one channel at all stages, and at low water the width is about 10 feet and the depth 0.5 feet. The section is good and gagings are made by wading.

The gage is a vertical staff, graduated to feet and tenths, and nailed to a post.

The following measurement was made December 7, 1906:

Width, 7 feet; area, 4 square feet; gage height, 0.50 foot; discharge, 5.9 second-feet.

*Daily gage height, in feet, of Tinemaha Creek near Tinemaha, Cal., for 1906.*

| Day. | Dec. | Day. | Dec. | Day. | Dec. | Day. | Dec. |
|---|---|---|---|---|---|---|---|
| 7 | 0.5 | 14 | 0.5 | 21 | 0.4 | 28 | 0.5 |
| 8 | .5 | 15 | .5 | 22 | .5 | 29 | .5 |
| 9 | .5 | 16 | .45 | 23 | .5 | 30 | .5 |
| 10 | .5 | 17 | .45 | 24 | .5 | 31 | .5 |
| 11 | .5 | 18 | .4 | 25 | .5 | | |
| 12 | .5 | 19 | .4 | 26 | .55 | | |
| 13 | .5 | 20 | .4 | 27 | .5 | | |

### TABOOSE CREEK NEAR TIBBETTS, CAL.

Taboose Creek is tributary to Owens River from the eastern slope of Sierra Nevada.

The station was not established regularly until August 20, 1906, though discharge measurements were made throughout the year. It is located about 15 miles north of Independence, 2 miles northwest of Tibbetts railway station, and about one-half mile west of the crossing on the lower main highway.

The channel is straight for about 50 feet above and 50 feet below the station, and the velocity is moderate. Both banks are rather steep and 3 to 4 feet high and are not likely to overflow. The bed and banks are sandy, with little vegetation, and the channel is subject to slight change. At low stages the stream is about 10 feet wide and 0.5 feet deep.

Discharge measurements are made from a board used as a footbridge.

The gage is a vertical staff, about 3.5 feet long, graduated to feet and tenths, and nailed securely to a post driven in the bank. The bench mark is a spike driven in the base of a cottonwood tree 2 feet south of gage; elevation, 3.75 feet above the zero of the gage.

*Discharge measurements of Taboose Creek near Tibbetts, Cal., by G. R. Shuey in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 18 | | | | 3.6 | May 23 | 7.8 | 7.4 | | 11 |
| February 21 | | | | 2.7 | June 1 | 7.8 | 5.9 | | 8.9 |
| March 20 | | | | 3.6 | June 11 | 7.0 | 7.8 | | 22 |
| March 27 | | | | 3.5 | July 2 | 8.0 | 10 | | 29 |
| April 6 | | | | 3.4 | July 7 | 10 | 14 | | 46 |
| April 12 | 7.0 | 3.2 | | 4.2 | July 14 | 10 | 15 | | 56 |
| April 19 | | | | 8.0 | July 27 | 8.5 | 12 | | 45 |
| April 24 | | | | 8.4 | August 2[a] | 6.0 | 6.9 | 2.35 | 23 |
| May 2 | 7.4 | 4.5 | | 6.8 | October 8[a] | 3.7 | 1.9 | 1.80 | 3.4 |
| May 8 | 8.0 | 7.1 | | 12 | December 8[a] | 4.0 | 1.8 | 1.65 | 3.6 |
| May 16 | 7.8 | 6.9 | | 12 | | | | | |

[a] Measured at regular station.

*Daily gage height, in feet, of Taboose Creek near Tibbetts, Cal., for 1906.*

| Day. | Aug. | Sept. | Oct. | Nov. | Dec. | Day. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 2.1 | 1.85 | | 1.75 | 17 | | 2.25 | 1.81 | 1.75 | |
| 2 | | 2.1 | 1.85 | | | 18 | | 2.28 | | | 1.6 |
| 3 | | 2.1 | 1.85 | 1.7 | 1.7 | 19 | 2.30 | 2.25 | | 1.75 | |
| 4 | | 2.2 | 1.85 | | | 20 | 2.32 | 2.15 | 1.80 | | 1.6 |
| 5 | | 2.2 | 1.85 | 1.7 | 1.7 | 21 | 2.35 | 2.1 | | 1.75 | |
| 6 | | 2.18 | 1.84 | | | 22 | 2.30 | 2.05 | | | 1.6 |
| 7 | | 2.2 | | 1.8 | 1.65 | 23 | 2.25 | 2.07 | 1.80 | | |
| 8 | | 2.18 | 1.80 | | 1.65 | 24 | | 1.95 | | 1.75 | 1.6 |
| 9 | | 2.2 | 1.82 | | | 25 | 2.15 | 1.9 | 1.80 | | |
| 10 | | 2.2 | | 1.75 | | 26 | 2.1 | 1.88 | | | 1.6 |
| 11 | | 2.2 | | | 1.65 | 27 | 2.1 | 1.9 | 1.8 | 1.75 | |
| 12 | | 2.2 | | | | 28 | 2.1 | 1.9 | | | |
| 13 | | 2.2 | 1.82 | 1.7 | 1.65 | 29 | 2.1 | 1.88 | 1.8 | 1.75 | 1.6 |
| 14 | | 2.25 | | | | 30 | 2.1 | 1.85 | | | |
| 15 | | 2.25 | 1.82 | 1.7 | 1.65 | 31 | 2.1 | | 1.78 | | |
| 16 | | 2.26 | | | | | | | | | |

*Monthly discharge of Taboose Creek near Tibbetts, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 4.0 | 3.3 | 3.7 | 228 |
| February | 3.0 | 2.7 | 2.9 | 161 |
| March | 3.6 | 3.0 | 3.3 | 203 |
| April | 8.4 | 3.4 | 5.8 | 345 |
| May | 12 | 6.8 | 10.4 | 640 |
| June | 28 | 9.0 | 21.8 | 1,300 |
| July | 56 | 29 | 46.3 | 2,850 |
| August | 40 | 15 | 25.7 | 1,580 |
| September | 21 | 5.6 | 15.0 | 833 |
| October | 5.6 | 3.2 | 3.7 | 228 |
| November | 4.0 | 3.0 | 3.6 | 214 |
| December | 4.0 | 3.0 | 3.5 | 215 |
| The year | 56 | 3.0 | 12.1 | 8,860 |

NOTE.—Daily discharge prior to August 19 was obtained by interpolation between measurements. Values are approximate.

## GOODALE CREEK NEAR TIBBETTS, CAL.

Goodale Creek is tributary to Owens River from the eastern slope of the Sierra Nevada.

The station was established September 20, 1906. It is located where the stream leaves the foothills, about 13 miles north of Independence, 4 miles west of Tibbetts railway station, and one-fourth mile west of the upper road crossing.

The channel is straight for 20 feet above and 15 feet below the measuring section, and the current is swift at all times. Both banks are low, clean, and sandy, but not likely to change materially. There is but one channel at all stages and discharge measurements are made from a plank used as a footbridge. At low water the stream is about 8 feet wide and nearly a foot deep.

The gage is a vertical staff nailed securely to a post driven in the bank. The reference bench mark is the top of a piece of steel driven in the ground about 5 feet south of gage and witnessed by a guard stake; elevation, 2.10 feet above the zero of the gage.

*Discharge measurements of Goodale Creek near Tibbetts, Cal., by G. R. Shuey, in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 12 | 4.0 | 1.8 | | 2.6 | June 19[a] | | | | 12 |
| April 24 | | | | 4.2 | July 2[a] | | | | 17 |
| May 2 | 4.0 | 1.8 | | 2.5 | July 7[a] | | | | 27 |
| May 9 | 4.7 | 2.9 | | 7.4 | July 14[a] | | | | 27 |
| May 16 | 4.7 | 2.9 | | 7.4 | July 27[a] | 4.4 | 4.1 | | 8.7 |
| May 23 | 5.0 | 3.5 | | 7.5 | October 31[b] | 5.6 | 3.4 | 0.60 | 5.4 |
| June 1 | 4.7 | 2.8 | | 4.9 | December 8[b] | 6.0 | 3.6 | .60 | 4.6 |
| June 11[a] | | | | 11 | | | | | |

[a] At upper road crossing. [b] At regular station.

*Daily gage height, in feet, of Goodale Creek near Tibbetts, Cal., for 1906.*

| Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.68 | | 0.60 | 12 | | | | 23 | 0.62 | | |
| 2 | | | | 13 | 0.60 | 0.60 | 0.55 | 24 | | 0.60 | 0.50 |
| 3 | .68 | 0.50 | .60 | 14 | | | | 25 | .60 | | |
| 4 | | | | 15 | .60 | .60 | .55 | 26 | | | .50 |
| 5 | | .50 | .60 | 16 | | | | 27 | .60 | .60 | |
| 6 | .65 | | | 17 | .62 | .65 | | 28 | | | |
| 7 | | .60 | .55 | 18 | | | .50 | 29 | .60 | .60 | .50 |
| 8 | | | .60 | 19 | | .65 | | 30 | | | |
| 9 | .62 | | | 20 | .60 | | .50 | 31 | .60 | | |
| 10 | | .55 | | 21 | | .65 | | | | | |
| 11 | .61 | | .55 | 22 | | | .50 | | | | |

*Monthly discharge of Goodale Creek near Tibbetts, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | | | [a] 2.0 | 123 |
| February | | | [a] 1.0 | 56 |
| March | | | [a] 1.0 | 61 |
| April | 4.2 | 2.6 | 3.5 | 208 |
| May | 7.5 | 2.5 | 6.3 | 387 |
| June | 16 | 4.9 | 11.2 | 666 |
| July | 27 | 6.8 | 19.0 | 1,170 |
| August | 6.6 | 6.2 | 6.4 | 394 |
| September | 6.3 | 4.8 | 5.9 | 351 |
| October | 6.3 | 5.4 | 5.6 | 344 |
| November | 5.6 | 5.0 | 5.3 | 315 |
| December | 4.6 | 4.0 | 4.3 | 264 |
| The year | 27 | | 6.0 | 4,340 |

[a] Estimated.

NOTE.—The daily discharge from April to September was obtained by interpolation between measurements. Values are approximate.

## DIVISION CREEK NEAR INDEPENDENCE, CAL.

Division Creek is tributary to Owens River from the eastern slope of Sierra Nevada, and measurements are made near where it leaves the foothills and enters the valley.

The station was established January 10, 1906, but no gage record was kept until September. It is located about 10 miles north of Independence on the upper road crossing, about 1½ miles west of the Ricky ranch house.

The channel is straight for about 10 feet above and 20 feet below the station. Both banks are low, and composed of gravel covered with weeds which extend a foot or two into the water; they are not subject to overflow. The bed is also of gravel, but is clean and not likely to change. The velocity is moderate and there is one channel at all stages. At low water the stream is 6 or 8 feet wide and about a foot deep. Discharge measurements are made from a plank used as a footbridge.

The gage is a vertical staff driven in the ground and nailed to a post. The bench mark is the top of a steel gad driven in the ground near a willow tree 20 feet west of gage; elevation, 4.45 feet above zero of gage.

*Discharge measurements of Division Creek near Independence, Cal., by G. R. Shuey, in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 18 | | | | 8.1 | May 16 | 6.5 | 3.3 | 2.26 | 7.5 |
| February 15 | | | 2.23 | 5.1 | May 23 | 6.5 | 3.3 | 2.26 | 7.5 |
| February 21 | | | 2.23 | 5.1 | June 1 | 6.2 | 3.1 | 2.25 | 6.0 |
| March 3 | | | | 5.0 | June 11 | 6.1 | 3.3 | 2.28 | 7.7 |
| March 15 | | | | 9.0 | June 19 | 6.1 | 3.7 | 2.30 | 9.2 |
| March 20 | | | | 5.4 | June 25 | 6.3 | 4.3 | 2.35 | 9.9 |
| March 27 | | | | 4.7 | July 2 | 6.3 | 4.2 | 2.40 | 11 |
| April 6 | | | | 4.9 | July 7 | 6.6 | 5.0 | 2.45 | 13 |
| April 12 | | 3.0 | 2.25 | 5.4 | July 14 | 7.0 | 6.7 | 2.65 | 17 |
| April 18 | | | 2.30 | 6.5 | July 27 | 6.5 | 7.1 | 2.95 | 22 |
| April 24 | | | | 7.4 | August 18[a] | 4.0 | 4.0 | 1.10 | 12 |
| May 2 | 6.4 | 3.0 | 2.25 | 6.6 | October 31 | 5.5 | 4.8 | 2.60 | 14 |
| May 9 | 6.6 | 3.3 | 2.30 | 7.9 | December 8 | 5.5 | 4.2 | 2.55 | 11 |

[a] Measured at ranch house.

*Daily gage height, in feet, of Division Creek near Independence, Cal., for 1906.*

| Day. | Aug. | Sept. | Oct. | Nov. | Dec. | Day. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1.1 | | | | 17 | | | | | |
| 2 | | 1.1 | | | 2.5 | 18 | 1.1 | | | 2.55 | |
| 3 | | 1.1 | | | | 19 | 1.1 | | | | |
| 4 | | 1.1 | | 2.6 | | 20 | 1.1 | | | | |
| 5 | | 1.1 | | | | 21 | 1.1 | | 2.6 | | |
| 6 | | 1.1 | | | | 22 | 1.1 | | | | |
| 7 | | 1.1 | 2.65 | | | 23 | 1.1 | 2.65 | | | 2.5 |
| 8 | | 1.1 | | | | 24 | 1.1 | | | | |
| 9 | | 1.1 | | | 2.55 | 25 | 1.1 | | | 2.4 | |
| 10 | | 1.1 | | | | 26 | 1.1 | | | | |
| 11 | | 1.1 | | 2.6 | | 27 | 1.1 | | | | |
| 12 | | 1.1 | | | | 28 | 1.1 | | 2.6 | | |
| 13 | | 1.1 | | | | 29 | 1.1 | | | | |
| 14 | | 1.1 | 2.62 | | | 30 | 1.1 | 2.65 | | | 2.5 |
| 15 | | 1.1 | | | | 31 | 1.1 | | 2.6 | | |
| 16 | | 1.1 | | | 2.5 | | | | | | |

NOTE.—From August 18 to September 18 the gage record was kept at the ranch house.

*Monthly discharge of Division Creek near Independence, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 8.1 | 5.3 | 6.7 | 412 |
| February | 5.3 | 5.0 | 5.1 | 283 |
| March | 9.0 | 4.7 | 6.1 | 375 |
| April | 7.4 | 4.8 | 6.0 | 357 |
| May | 7.9 | 6.1 | 7.3 | 449 |
| June | 10 | 6.0 | 8.4 | 500 |
| July | 22 | 10 | 17.2 | 1,060 |
| August | 20 | 12 | 14.3 | 879 |
| September | 12 | 10 | 10.9 | 649 |
| October | 14 | 10 | 12.6 | 775 |
| November | 14 | 8.0 | 11.5 | 684 |
| December | 11 | 10 | 10.1 | 621 |
| The year | 22 | 4.7 | 9.7 | 7,040 |

NOTE.—The daily discharge prior to August 18 was obtained by interpolation between measurements. Values are approximate.

## EIGHTMILE CREEK NEAR INDEPENDENCE, CAL.

Eightmile Creek is tributary to Owens River from the eastern slope of Sierra Nevada; measurements are made near where the stream leaves the foothills and enters the valley.

The station was established September 20, 1906. It is located on the upper road crossing about 8 miles north of Independence and about 300 feet beyond the Eightmile ranch.

The channel is straight for about 15 feet above and 10 feet below the station. The bottom is of gravel, not likely to shift, but both banks are very low and liable to overflow. The velocity is high and there is only one channel at low water, but at high water there are two or three. At low water the stream has a width of about 6 feet and a depth of 0.5 foot. Measurements are made from a plank used as a footbridge.

The gage is a staff graduated into feet and tenths and nailed to a post. The bench mark is a spike driven in fence post 10 feet east of gage; elevation, 1.49 feet above the zero of the gage. During 1906 no gage-height record was kept.

*Discharge measurements of Eightmile Creek near Independence, Cal., by G. R. Shuey, in 1906.*

| Date. | Width. | Area of section. | Discharge. | Date. | Width. | Area of section. | Discharge. |
|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. Ft.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Sec.-ft.* |
| February 15 | | | 2.7 | May 23 | | | 4.4 |
| March 3 | | | 2.5 | June 1 | 4.0 | 1.8 | 4.6 |
| March 15 | | | 5.0 | June 19 | 4.0 | 2.0 | 7.8 |
| March 27 | | | 3.4 | June 25 | 4.0 | 2.6 | 9.2 |
| April 6 | | | 3.0 | July 7 | | | 17 |
| April 18 | | | 3.4 | July 27 | 9.5 | 5.1 | 14 |
| April 24 | 4.0 | 1.6 | 4.1 | August 18 | 3.2 | 3.2 | 13 |
| May 2 | 4.0 | 1.6 | 3.7 | October 31[a] | 6.0 | 2.8 | 5.0 |
| May 9 | 4.0 | 1.6 | 4.5 | December 8 | 8.0 | 3.5 | 5.0 |
| May 16 | 4.0 | 1.6 | 4.4 | | | | |

[a] Gage height 0.40 foot at regular station.

*Monthly discharge of Eightmile Creek near Independence, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | | | [a] 3.0 | 184 |
| February | 2.8 | 2.5 | 2.7 | 150 |
| March | 5.0 | 2.5 | 3.7 | 228 |
| April | 4.1 | 3.0 | 3.4 | 202 |
| May | 4.6 | 3.7 | 4.3 | 264 |
| June | 13 | 4.6 | 7.6 | 452 |
| July | 20 | 13 | 16.3 | 1,000 |
| August | 14 | 11 | 12.6 | 775 |
| September | 11 | 8.3 | 9.8 | 583 |
| October | 8.2 | 5.0 | 6.7 | 412 |
| November | | | [a] 5.0 | 298 |
| December | | | [a] 5.0 | 307 |
| The year | | | 6.7 | 4,860 |

[a] Estimated.

NOTE.—The daily discharge, February to October, was obtained by interpolation between measurements. Values are approximate.

## OAK CREEK NEAR INDEPENDENCE, CAL.

This station was established June 15, 1905, about 1 mile west of old Fort Independence. The conditions and the bench marks are described in Water-Supply Paper No. 177, page 83.

A new station was established October 1, 1906. It is located at Bell's flour mill, about 3 miles northwest of Independence, and just above the division boxes which divide the stream into three parts.

The channel at the point of measurement is a flume 12 feet wide and 1 foot deep, with a gravel bottom which has to be cleaned out after high water. At very high stages the stream divides above the flume and forms two channels. Measurements are made by wading or from a plank used as a footbridge.

The gage is a staff nailed to a post on the north side of the stream.

*Discharge measurements of Oak Creek near Independence, Cal., by G. R. Shuey, in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 14 | | | 0.20 | 7.7 | May 23 | 5 | 7.7 | 1.08 | 34 |
| February 21 | | | .20 | 7.1 | June 3 | 5 | 7.7 | 1.08 | 36 |
| March 3 | | | | 7.5 | June 16[a] | | | | 60 |
| March 10 | | | | 7.5 | June 23 | 18 | 21 | | 93 |
| March 20 | | | | 7.5 | July 7 | 18 | 26 | | 162 |
| March 27 | | | | 8.9 | July 14 | 17 | 24 | | 143 |
| April 6 | | | | 8.5 | July 27 | 16 | 23 | | 132 |
| April 12 | 4 | 3.5 | .30 | 10 | August 9 | 16 | 22 | | 77 |
| April 21 | 4 | 4.3 | .50 | 14 | August 20 | 14 | 20 | | 68 |
| April 24 | 4 | 4.6 | .50 | 17 | September 23 | | 6.0 | | 21 |
| May 2 | 4 | 4.1 | .44 | 14 | October 20 | 12 | 4.8 | .35 | 17 |
| May 9 | 4 | 6.5 | .90 | 26 | November 19 | 12 | 5.6 | .30 | 12.4 |
| May 14 | 5 | 6.9 | .98 | 27 | December 21 | 12 | 5.6 | .25 | 10.6 |

[a] Measured in two channels.

*Daily gage height, in feet, of Oak Creek near Independence, Cal., for 1906.*

| Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.40 | 0.30 | 0.20 | 12 | 0.40 | 0.30 | 0.30 | 23 | 0.37 | 0.25 | 0.25 |
| 2 | .40 | .30 | .25 | 13 | .40 | .30 | .30 | 24 | .36 | .25 | .25 |
| 3 | .40 | .30 | .30 | 14 | .40 | .30 | .30 | 25 | .36 | .25 | .25 |
| 4 | .41 | .30 | .30 | 15 | .40 | .30 | .30 | 26 | .36 | .25 | .25 |
| 5 | .42 | .30 | .30 | 16 | .39 | .30 | .30 | 27 | .35 | .20 | .25 |
| 6 | .40 | .30 | .30 | 17 | .39 | .30 | .25 | 28 | .35 | .20 | .25 |
| 7 | .40 | .30 | .30 | 18 | .38 | .30 | .25 | 29 | .30 | .20 | .25 |
| 8 | .40 | .30 | .30 | 19 | .38 | .30 | .25 | 30 | .30 | .20 | .20 |
| 9 | .40 | .30 | .30 | 20 | .35 | .30 | .25 | 31 | .30 | | .20 |
| 10 | .40 | .30 | .30 | 21 | .35 | .30 | .25 | | | | |
| 11 | .40 | .30 | .30 | 22 | .35 | .30 | .20 | | | | |

*Monthly discharge of Oak Creek near Independence, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | | | [a] 6.0 | 369 |
| February | 7.7 | 7.1 | 7.3 | 405 |
| March | 8.9 | 7.4 | 7.8 | 480 |
| April | 17 | 8.5 | 11.9 | 708 |
| May | 36 | 14 | 28.0 | 1,720 |
| June | 128 | 36 | 69.9 | 4,160 |
| July | 162 | 113 | 140 | 8,610 |
| August | 109 | 53 | 73.5 | 4,520 |
| September | 51 | 20 | 32.2 | 1,920 |
| October | 26 | 12 | 20.5 | 1,260 |
| November | 12 | 10 | 11.8 | 702 |
| December | 12 | 10 | 11.3 | 695 |
| The year | 162 | | 35.0 | 25,500 |

[a] Estimated.

NOTE.—The daily discharge February to September was obtained by interpolation between measurements; after October 1 a rating table, based on three discharge measurements, was used; values are approximate.

## INDEPENDENCE CREEK NEAR INDEPENDENCE, CAL.

The old station at the city waterworks, which was established June 15, 1905, was wrecked in June, 1906, and a new station was established on August 20, 1906. It is located about 1 mile west of the town of Independence and about 300 feet above the waterworks for the town.

The channel is straight for about 40 feet above and 30 feet below the station. Both banks are high and rocky and not liable to overflow. The bed is also rocky, but clean and fairly permanent. There is one channel at all stages and the velocity is high. At very high stages the section may change on account of the displacement of bowlders. Measurements are made from a plank used as a footbridge. At low water the stream is about 10 feet wide and 0.5 foot deep.

The gage is a staff nailed to a post on the south bank of the creek. The bench mark is a spike driven in a willow tree about 10 feet east of gage on south bank; elevation, 1.32 feet above zero of gage.

*Discharge measurements of Independence Creek near Independence, Cal., in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 23 | | | 0.42 | 4.5 | June 4 | 8 | 8.6 | 0.85 | 31 |
| January 30 | | | | 2.8 | June 12 | 13 | 18 | 1.55 | 86 |
| February 13 | | | .36 | 2.4 | June 23 | 11 | 17 | | 130 |
| March 2 | | | | 4.6 | July 1 | 11 | 16 | | 116 |
| March 25 | | | | 4.9 | July 9 | 11 | 20 | | 144 |
| April 5 | | | | 5.0 | July 19 | 11 | 22 | | 137 |
| April 14 | 9 | 4.6 | .50 | 6.6 | August 9 | | | | 60 |
| April 22 | 10 | 5.9 | .60 | 11 | September 11 | 11 | 13 | .90 | 26 |
| April 30 | 9 | 6.1 | .61 | 11 | September 23 | 11 | 9.1 | .67 | 16 |
| May 10 | 10 | 7.5 | .80 | 25 | October 20 | 10 | 6.6 | .50 | 7.5 |
| May 22 | 10 | 11 | .98 | 43 | November 13 | 10 | 6.6 | .45 | 5.0 |
| May 29 | 9 | 9.4 | .87 | 32 | | | | | |

NOTE.—Measurements January to August were made at old station; the gage was out after June 12. Measurements September to November were made at new station.

*Daily gage height, in feet, of Independence Creek near Independence, Cal., for 1906.*

| Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0.6 | | | 12 | | | 0.4 | 0.4 | 23 | 0.67 | | | |
| 2 | | | 0.5 | 0.5 | 13 | 0.8 | 0.6 | .45 | | 24 | | | 0.4 | 0.4 |
| 3 | 0.9 | .6 | | | 14 | | | .5 | .4 | 25 | .7 | | | |
| 4 | | | .5 | .5 | 15 | .8 | .6 | | | 26 | | | .5 | .4 |
| 5 | .9 | .6 | | | 16 | | | .4 | .5 | 27 | .6 | | | |
| 6 | | | .4 | .4 | 17 | .8 | | | | 28 | | | .4 | .5 |
| 7 | .9 | | | | 18 | | .6 | .4 | .4 | 29 | .7 | | | |
| 8 | | | .5 | .4 | 19 | .8 | | | | 30 | | | | .4 |
| 9 | | | | | 20 | | .5 | .5 | .4 | 31 | | | | .4 |
| 10 | | | .5 | .4 | 21 | .7 | .7 | | | | | | | |
| 11 | .9 | .7 | | | 22 | | .6 | .5 | .5 | | | | | |

*Monthly discharge of Independence Creek near Independence, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 4.5 | 2.8 | 4.0 | 246 |
| February | 4.2 | 2.4 | 2.8 | 156 |
| March | 5.0 | 4.4 | 4.8 | 295 |
| April | 11 | 5.0 | 8.0 | 476 |
| May | 43 | 12 | 29.6 | 1,820 |
| June | 226 | 31 | 96.4 | 5,740 |
| July | 144 | 88 | 127 | 7,810 |
| August | 84 | 37 | 54.4 | 3,340 |
| September | 36 | 15 | 22.9 | 1,360 |
| October | 16 | 7.5 | 12.4 | 762 |
| November | 10 | 4.0 | 6.1 | 363 |
| December | 7.5 | 4.0 | 5.2 | 320 |
| The year | 226 | 2.4 | 31.1 | 22,700 |

NOTE.—The daily discharge, January to August, was obtained by interpolation between measurements. Values are approximate.

## SHEPHERDS CREEK NEAR INDEPENDENCE, CAL.

Shepherds Creek is tributary to Owens River from the eastern slope of Sierra Nevada. No regular station has been established on this stream, but a sufficient number of measurements have been made during 1906 to warrant a rough estimate of the yearly flow. All measurements have been made near the foothills.

*Discharge measurements of Shepherds Creek near Independence, Cal., by G. R. Shucy, in 1906.*

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Sec.-ft.* | | *Sec.-ft.* |
| February 7 | 1.7 | June 21 | 95 |
| April 14 | 6.2 | June 29 | 70 |
| April 22 | 16 | July 9 | 109 |
| May 1 | 9.8 | July 23 | 111 |
| May 10 | 34 | September 10 | 11 |
| May 18 | 32 | October 22 | 1.2 |
| May 26 | 27 | November 14 | .3 |
| June 2 | 15 | December 19 | 3.4 |
| June 12 | 60 | | |

*Monthly discharge of Shepherds Creek near Independence, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | | | 2.0 | 123 |
| February | | | 2.0 | 111 |
| March | | | 2.0 | 123 |
| April | 16 | 4.5 | 9.0 | 536 |
| May | 34 | 9.8 | 26.5 | 1,630 |
| June | 95 | 15 | 62.2 | 3,700 |
| July | 111 | 78 | 104 | 6,400 |
| August | 93 | 33 | 63.0 | 3,870 |
| September | 31 | 5.5 | 12.0 | 714 |
| October | 5.3 | 1.0 | 2.6 | 160 |
| November | | | .5 | 30 |
| December | | | 3.0 | 184 |
| The year | | | 24.1 | 17,600 |

NOTE.—The daily discharge, April to October, was obtained by interpolation between measurements; mean for other months estimated. Values are approximate.

## MOFFETT CREEK NEAR INDEPENDENCE, CAL.

Moffett Creek is tributary to Owens River from the eastern slope of the Sierra Nevada. No regular station has been established but during 1906 enough measurements were made to justify a rough estimate of the yearly flow. All measurements were made near the foothills.

*Discharge measurements of Moffett Creek near Independence, Cal., by G. R. Shuey, in 1906.*

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Sec.-ft.* | | *Sec.-ft.* |
| April 14 | 1.5 | June 21 [a] | 44 |
| April 22 [a] | 6.5 | June 29 [a] | 27 |
| May 1 [a] | 3.9 | July 9 | 39 |
| May 10 [a] | 14 | July 23 [a] | 28 |
| May 18 | 14 | September 10 [a] | 3.9 |
| May 26 | 15 | October 22 [a] | 1.6 |
| June 2 | 10 | December 19 [b] | .2 |
| June 12 | 37 | | |

[a] Measured at diversion gates. [b] Estimated.

*Monthly discharge of Moffett Creek near Independence, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | | | 1.0 | 61 |
| February | | | 1.0 | 56 |
| March | | | 1.0 | 61 |
| April | 6.5 | 1.5 | 3.2 | 190 |
| May | 15 | 3.9 | 12.5 | 769 |
| June | 44 | 10 | 31.3 | 1,860 |
| July | 39 | 19 | 30.3 | 1,860 |
| August | 19 | 8.2 | 13.4 | 824 |
| September | 7.8 | 2.9 | 4.3 | 256 |
| October | 2.9 | 1.3 | 2.0 | 123 |
| November | | | 1.0 | 60 |
| December | | | .5 | 31 |
| The year | | | 8.5 | 6,150 |

NOTE.—The daily discharge April to October was obtained by interpolation between measurements; mean for other months estimated. Values are approximate.

## GEORGES CREEK NEAR INDEPENDENCE, CAL.

Georges Creek is a tributary to Owens River from the eastern slope of the Sierra Nevada. No regular station has been established, but enough measurements were made during 1906 to warrant a rough estimate of the flow for the year. Measurements were made at or above the division gates.

*Discharge measurements of Georges Creek near Independence, Cal., by G. R. Shuey, in 1906.*

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Sec.-ft.* | | *Sec.-ft.* |
| February 7 | 1.0 | June 29 | 66 |
| April 14 | 5.1 | July 9 | 84 |
| April 22 | 14 | July 23 | 102 |
| May 1 | 7.4 | August 10 | 42 |
| May 10 | 21 | October 22 | 4.5 |
| May 18 | 28 | October 30 | 3.1 |
| May 26 | 20 | December 19 | 1.6 |
| June 12 | 53 | | |

*Monthly discharge of Georges Creek near Independence, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | | | [a] 1.0 | 61 |
| February | | | [a] 1.0 | 56 |
| March | | | [a] 2.0 | 123 |
| April | 14 | | 10.3 | 613 |
| May | 29 | 7.4 | 21.1 | 1,300 |
| June | 68 | 31 | 52.9 | 3,150 |
| July | 102 | 70 | 86.9 | 5,340 |
| August | 72 | 29 | 42.3 | 2,600 |
| September | 29 | 14 | 21.0 | 1,250 |
| October | 14 | 3.0 | 7.7 | 473 |
| November | 3.0 | 2.1 | 2.6 | 155 |
| December | 2.1 | 1.4 | 1.7 | 105 |
| The year | 102 | | 20.9 | 15,200 |

[a] Estimated.

NOTE.—The daily discharge April to November was obtained by interpolation between measurements. Values are approximate.

## LONE PINE CREEK NEAR LONE PINE, CAL.

Lone Pine Creek is tributary to Owens River from the eastern slope of the Sierra Nevada. The station was established September 25, 1906. It is located about three-fourths mile west of the town of Lone Pine and about 500 feet above the division boxes on the creek.

The channel is straight for 30 feet above and 20 feet below the station. Both banks are high and rocky and not subject to overflow. The bed is rocky and not likely to change, but the cross section is rough and uneven. There is one channel at all stages and the current is swift. At low water the stream is 7 feet wide and 0.8 foot deep. Measurements are made by wading or from a plank used as a footbridge.

The gage is a staff graduated to feet and tenths and is nailed securely to a post. The bench mark is a spike driven in the base of a birch tree on the south bank near the station; elevation, 4.85 feet above zero of gage.

*Discharge measurements of Lone Pine Creek near Lone Pine, Cal., by G. R. Shuey, in 1906.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| January 31 | | 3.1 | June 13 | | 66 |
| February 17 | | 3.1 | June 21 | | 90 |
| February 24 | | 2.2 | June 29 | | 100 |
| March 13 | | 4.0 | July 10 | | 134 |
| March 23 | | 4.0 | July 25 | | 139 |
| March 29 | | 4.4 | August 10 | | 72 |
| April 15 | | 5.5 | September 6 | | 36 |
| April 28 | | 12 | September 24[a] | 1.92 | 18 |
| May 10 | | 26 | October 23[a] | 1.80 | 13 |
| May 17 | | 33 | November 20[a] | 1.70 | 8 |
| May 26 | | 32 | | | |

[a] Measured at regular station.

*Daily gage height, in feet, of Lone Pine Creek near Lone Pine Cal., for 1906.*

| Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.89 | | 1.7 | 12 | 1.81 | 1.7 | | 23 | 1.8 | 1.7 | 1.7 |
| 2 | | 1.7 | | 13 | | | 1.7 | 24 | | | |
| 3 | 1.89 | | 1.7 | 14 | | | | 25 | | 1.7 | 1.7 |
| 4 | | 1.7 | | 15 | | 1.7 | 1.7 | 26 | | | |
| 5 | 1.89 | | 1.7 | 16 | | | | 27 | | | 1.7 |
| 6 | | 1.7 | | 17 | | | 1.7 | 28 | | 1.7 | |
| 7 | | | 1.7 | 18 | | | | 29 | | | 1.7 |
| 8 | 1.89 | 1.7 | | 19 | | 1.7 | 1.7 | 30 | | 1.7 | |
| 9 | | | 1.7 | 20 | | 1.7 | | 31 | | | 1.7 |
| 10 | 1.83 | | | 21 | | 1.7 | 1.7 | | | | |
| 11 | | | 1.7 | 22 | | | | | | | |

*Monthly discharge of Lone Pine Creek near Lone Pine, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | | | [a]3.0 | 184 |
| February | 3.1 | 2.2 | 2.9 | 161 |
| March | 4.5 | 2.7 | 3.8 | 234 |
| April | 14 | 4.5 | 7.2 | 428 |
| May | 40 | 15 | 28.5 | 1,750 |
| June | 103 | 42 | 73.5 | 4,370 |
| July | 139 | 106 | 129 | 7,930 |
| August | 111 | 44 | 68.4 | 4,210 |
| September | 43 | 17 | 27.2 | 1,620 |
| October | 16 | 12 | 14.0 | 861 |
| November | 8.0 | 8.0 | 8.0 | 476 |
| December | 8.0 | 8.0 | 8.0 | 492 |
| The year | 139 | 2.2 | 31.1 | 22,700 |

[a] Estimated.

NOTE.—The daily discharge January to September was obtained by interpolation between measurements. Values are approximate.

## TUTTLE CREEK NEAR LONE PINE, CAL.

Tuttle Creek is tributary to Owens River from the eastern slope of the Sierra Nevada. During 1906 measurements were made regularly at a point near Lone Pine, where the stream leaves the foothills and

enters the valley. These measurements are numerous enough to warrant a monthly estimate of the flow of the stream for the year. A gage-height record has been kept during November and December.

*Discharge measurements of Tuttle Creek near Lone Pine, Cal., by G. R. Shuey, in 1906.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| January 31 | | 4.9 | June 13 | 1.15 | 20 |
| February 17 | 0.90 | 5.0 | June 21 | 1.45 | 32 |
| February 24 | .90 | 4.4 | June 29 | 1.60 | 39 |
| March 13 | | 4.2 | July 25 | | 67 |
| March 23 | | 4.2 | August 11 | 1.65 | 35 |
| March 29 | | 4.6 | September 6 | 1.40 | 18 |
| April 15 | .87 | 4.6 | September 25 | 1.18 | 11 |
| May 11 | .98 | 10 | October 24 | 1.12 | 9.5 |
| May 18 | 1.02 | 12 | November 20 | 1.13 | 8.5 |
| May 26 | 1.05 | 13 | | | |

*Daily gage height, in feet, of Tuttle Creek near Lone Pine, Cal., for 1906.*

| Day. | Nov. | Dec. | Day. | Nov. | Dec. | Day. | Nov. | Dec. | Day. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1.1 | 9 | | 1.1 | 17 | | | 25 | 1.15 | |
| 2 | 1.1 | | 10 | 1.1 | | 18 | | 1.1 | 26 | | 1.1 |
| 3 | | 1.1 | 11 | | 1.1 | 19 | 1.15 | | 27 | | |
| 4 | 1.1 | | 12 | 1.15 | | 20 | 1.13 | 1.1 | 28 | 1.1 | 1.1 |
| 5 | | 1.1 | 13 | | 1.1 | 21 | 1.15 | | 29 | | |
| 6 | 1.1 | | 14 | | | 22 | | 1.1 | 30 | 1.1 | 1.1 |
| 7 | | 1.1 | 15 | | 1.1 | 23 | 1.15 | | 31 | | |
| 8 | 1.1 | | 16 | | | 24 | | 1.1 | | | |

*Monthly discharge of Tuttle Creek near Lone Pine, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | | | [a] 5.0 | 307 |
| February | 5.0 | 4.4 | 4.8 | 267 |
| March | 4.6 | 4.2 | 4.3 | 264 |
| April | 7.6 | 4.6 | 5.4 | 321 |
| May | 15 | 7.8 | 11.1 | 682 |
| June | 40 | 16 | 26.0 | 1,550 |
| July | 67 | 41 | 54.1 | 3,330 |
| August | 51 | 22 | 53.1 | 2,040 |
| September | 21 | 10 | 14.2 | 845 |
| October | 11 | 9.5 | 9.6 | 590 |
| November | 10 | 8.0 | 9.0 | 536 |
| December | 8.0 | 8.0 | 8.0 | 492 |
| The year | 67 | | 15.4 | 11,200 |

[a] Estimated.

NOTE.—The daily discharge February to December was obtained by interpolation between measurements. Values are approximate.

## COTTONWOOD CREEK NEAR OLANCHA, CAL.

Cottonwood Creek discharges into Owens Lake from the Sierra Nevada; measurements are made near the foothills.

The station was established September 25, 1906. It is located about 15 miles south of Lone Pine and about one-fourth mile above the point of crossing of the Los Angeles conduit.

The channel is straight for about 40 feet above and 50 feet below the station. The right bank is high, rocky, and wooded; the left is comparatively low and not wooded; but neither bank is likely to overflow. The bed is rocky and permanent, and there is but one channel at all stages, but the current is very swift. At low water the stream is about 10 feet wide and 1 foot deep. Measurements are made from a plank used as a footbridge.

The gage is a staff nailed to a post.

*Discharge measurements of Cottonwood Creek near Olancha, Cal., by G. R. Shuey, in 1906.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| January 6 | | 5.6 | June 28 | | 300 |
| March 29 | | 12 | July 10 | | 249 |
| April 20 | | 28 | July 24 | | 190 |
| April 27 | | 31 | August 12 | | 104 |
| May 19 | | 158 | September 26 [a] | 0.80 | 22 |
| May 27 | | 131 | October 26 [a] | .74 | 17 |
| June 13 | | 434 | November 21 [a] | .50 | 9.3 |

[a] Measured at regular station.

*Daily gage height, in feet, of Cottonwood Creek near Olancha, Cal., for 1906.*

| Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0.8 | 0.7 | 0.5 | 12 | | 0.7 | | | 23 | | 0.5 | 0.6 | |
| 2 | | .8 | .75 | | 13 | | .7 | | 0.6 | 24 | | .7 | | |
| 3 | | .8 | .75 | | 14 | | .7 | | | 25 | | .75 | .5 | 0.6 |
| 4 | | .8 | | .5 | 15 | | .7 | | .8 | 26 | 0.8 | .74 | | |
| 5 | | .75 | | | 16 | | .7 | 0.6 | | 27 | .8 | .7 | .5 | .6 |
| 6 | | .7 | | | 17 | | .65 | | | 28 | .8 | .7 | | |
| 7 | | .7 | | .5 | 18 | | .65 | .6 | .6 | 29 | .8 | .65 | .5 | .6 |
| 8 | | .7 | | | 19 | | .6 | | | 30 | .8 | .70 | | |
| 9 | | .7 | | .6 | 20 | | .5 | | .6 | 31 | | .65 | | |
| 10 | | .7 | | | 21 | | .5 | .5 | | | | | | |
| 11 | | .7 | | .6 | 22 | | .65 | | .6 | | | | | |

*Monthly discharge of Cottonwood Creek near Olancha, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 7.4 | 5.5 | 6.2 | 381 |
| February | 9.4 | 7.4 | 8.2 | 455 |
| March | 13 | 9.5 | 10.9 | 670 |
| April | 35 | 14 | 24.2 | 1,440 |
| May | 158 | 40 | 114 | 7,010 |
| June | 434 | 172 | 333 | 19,800 |
| July | 287 | 166 | 225 | 13,800 |
| August | 161 | 70 | 104 | 6,400 |
| September | 68 | 22 | 42.4 | 2,520 |
| October | 22 | 10 | 15.9 | 978 |
| November | 17 | 9.0 | 13.3 | 791 |
| December | 22 | 9.0 | 12.8 | 787 |
| The year | 434 | 5.5 | 75.8 | 55,000 |

NOTE.—The daily discharge January to September was obtained by interpolation between measurements. During high water measurements were made below the point of diversion, so that the discharge is probably too low. Values are approximate.

### ASH CREEK NEAR LONE PINE, CAL.

Ash Creek discharges into Owens Lake from the eastern slope of the Sierra Nevada. Numerous measurements have been made on this stream during 1906, but they have not been made at the same point, although all were above the point of diversion.

*Discharge measurements of Ash Creek near Lone Pine, Cal., by G. R. Shuey in 1906.*

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Sec.-ft.* | | *Sec.-ft.* |
| January 6 | 1.3 | June 29 | 58 |
| March 2 | 4.8 | July 10 | 31 |
| April 27 | 10.7 | August 13 | 5.9 |
| May 19 | 16 | September 26 | 3.2 |
| May 27 | 16 | October 26 | 2.8 |
| June 14 | 21 | November 21 | 2.4 |

*Monthly discharge of Ash Creek near Lone Pine, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 2.2 | 1.3 | 1.7 | 105 |
| February | 3.8 | 2.4 | 3.2 | 178 |
| March | 5.2 | 4.0 | 4.5 | 277 |
| April | 11 | 5.4 | 8.3 | 494 |
| May | 17 | 12 | 14.8 | 910 |
| June | 58 | 17 | 30.6 | 1,820 |
| July | 53 | 9.0 | 25.3 | 1,560 |
| August | 8.5 | 5.0 | 5.8 | 357 |
| September | 5.0 | 3.2 | 4.0 | 238 |
| October | 3.2 | 2.8 | 3.0 | 184 |
| November | 2.7 | 2.4 | 2.5 | 149 |
| December | | | *a* 2.2 | 135 |
| The year | 5.8 | 1.3 | 8.8 | 6,410 |

*a* Estimated.

NOTE.—The daily discharge January to November was obtained by interpolation between measurements. Values are approximate.

### MISCELLANEOUS MEASUREMENTS IN OWENS RIVER DRAINAGE BASIN.

The following is a list of the miscellaneous discharge measurements made in the Owens River drainage basin during 1906:

*Black Rock Springs near Independence, Cal.*—These springs are near the foothills, about 8 miles northwest of Independence, and the water from them discharges into Owens River. The following measurement was made December 12, 1906, at the point where the water emerges from the ground.

Width, 11 feet; area, 19 square feet; discharge, 27 second-feet.

*Cottonwood Creek near Lone Pine, Cal.*—This stream discharges into Owens Lake from the eastern slope of the Sierra Nevada. The following measurement was made September 26, 1906, at the mouth of the canyon where the stream enters the valley:

Width, 10 feet; area, 12 square feet; discharge, 25 second-feet.

*Fish Springs near Tinemaha, Cal.*—These springs are near the foothills, about 8 miles south of Big Pine, and the water from them discharges into Owens River. The following measurement was made December 7, 1906, in a flume near their source:

Width, 7 feet; area, 20 square feet; discharge, 36 second-feet.

*Georges Creek near Independence, Cal.*—This stream is tributary to Owens River from the eastern slope of Sierra Nevada. The following measurements were made in 1906, at the mouth of the canyon where the stream enters the valley:

September 7: Discharge, 25 second-feet.
October 30: Discharge, 4.8 second-feet.

*Independence Creek near Independence, Cal.*—This creek is tributary to Owens River from the Sierra Nevada. The following measurements were made in 1906:

September 11, at mouth of canyon: Area, 11 square feet; discharge, 28 second-feet.
November 13, at Pinon ditch: Width, 5.4 feet; area, 3.3 square feet; discharge, 5.3 second-feet.

*Lone Pine Creek near Lone Pine, Cal.*—This stream is tributary to Owens River from the eastern slope of the Sierra Nevada. The following measurements were made in 1906, at the mouth of the canyon where the stream enters the valley:

September 8: Width, 10 feet; area, 12 square feet; discharge, 31 second-feet.
September 24: Area, 9.3 square feet; discharge, 20 second-feet.
October 23: Width, 8.3 feet; area, 6.7 square feet; discharge, 10 second-feet.

*North Fork Oak Creek near Independence, Cal.*—This stream is tributary to Owens River from the eastern slope of the Sierra Nevada. The following measurements were made in 1906:

August 20, in canyon: Area, 7.8 square feet; discharge, 49 second-feet.
November 17, 3 miles above junction with South Fork: Width, 4.3 feet; area, 4.2 square feet; discharge, 12 second-feet.
November 19, at junction with South Fork: Width, 8 feet; area, 4.6 square feet; discharge, 12 second-feet.

*South Fork Oak Creek near Independence, Cal.*—This stream is south of North Fork and is tributary to Owens River from the eastern slope of the Sierra Nevada. The following measurements were made in 1906:

August 20, in Canyon: Area, 9.9 square feet; discharge, 52 second-feet.
November 19, at junction with North Fork: Width, 6.5 feet; area, 3.3 square feet; discharge, 4.3 second-feet.

*Shepherds Creek near Independence, Cal.*—This stream is tributary to Owens River from the eastern slope of the Sierra Nevada. The following measurements were made November 14, 1906:

At mouth of canyon: Width, 6.5 feet; area, 3.9 square feet; dishcarge, 5.4 second-feet.
At fork 4 miles east of canyon: Width, 6 feet; area, 4 square feet; discharge, 3.5 second-feet.

*Taboose Creek near Tibbetts, Cal.*—This creek is tributary to Owens River from the eastern slope of the Sierra Nevada. On December 8, 1906, a measurement was made on the upper road crossing 2 miles above gaging station.

Width, 8 feet; area, 3.6 square feet; discharge, 5.4 second-feet.

*Thebaut Creek near Independence, Cal.*—This stream is tributary to Owens River from the eastern slope of the Sierra Nevada. On November 17, 1906, the following measurement was made at the mouth of the canyon where it enters the valley:

Width, 1.4 feet; area, 0.5 square foot; discharge, 1.6 second-feet.

## MOHAVE RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

The Mohave River rises on the northern slope of the San Bernardino Mountains, and, flowing in a northerly direction, finally disappears in the sands of the Mohave Desert. This stream has few tributaries, the only ones of importance being West Fork and Deep Creek, which have their source in the higher elevations of the San Bernardino Mountains. The formation is of granite, with a good covering of soil. On the higher elevations there is a considerable growth of timber, which diminishes as one approaches the lower reaches, changing to a light growth of brush and grass, finally merging into the barren desert. During the greater portion of the year the stream bed is dry below the junction of West Fork and Deep Creek, where the waters disappear in the sand and gravelly bed of the stream. Water again rises at a point lower down on the river above Victorville, where the gaging station is located. Water is diverted above and below the gaging station, but is again returned to the river channel. There are several artesian wells along the river above the gaging station, the water being used for irrigation. This stream does not discharge in any large quantity except during an extremely heavy rainfall in the winter months. The precipitation throughout this basin is very light, with the possible exception of the higher elevation of the San Bernardino Mountains, where there is a considerable fall of snow during the winter months, which melts in the early spring.

### MOHAVE RIVER AT VICTORVILLE, CAL.

This station was established February 27, 1899, and discontinued July 31, 1906. It is located in the town of Victorville, a station on the Atchison, Topeka and Santa Fe Railroad, where the Mohave River passes through a narrow gorge locally known as the "Narrows." The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 87, where are given also references to publications that contain data for previous years.

The gage heights observed at this station in 1906 are of no value, therefore no discharges have been computed.

*Discharge measurements of Mohave River at Victorville, Cal., by P. H. Leahy in 1906.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| January 2 | 4.03 | 65 | March 28[a] | 4.40 | 1,240 |
| January 6 | | 63 | March 30 | 4.30 | 1,430 |
| January 9 | 4.03 | 67 | March 31 | 4.30 | 965 |
| January 12 | 4.09 | 66 | April 2 | 4.60 | 682 |
| January 16 | | 66 | April 6 | 4.50 | 647 |
| January 20 | 4.17 | 88 | April 10 | 4.50 | 525 |
| January 23 | 4.11 | 62 | April 13 | 4.30 | 401 |
| January 26 | 4.10 | 72 | April 17 | 4.20 | 348 |
| January 31 | 4.10 | 65 | April 20 | 4.20 | 273 |
| February 2 | 4.10 | 64 | April 24 | 4.10 | 202 |
| February 6 | 4.10 | 67 | April 28 | 4.20 | 222 |
| February 10 | 4.10 | 68 | May 1 | 4.20 | 224 |
| February 15 | 4.11 | 64 | May 5 | 4.20 | 202 |
| February 17 | 4.11 | 50 | May 11 | 4.00 | 125 |
| February 21 | 4.12 | 79 | May 19 | 4.00 | 42 |
| February 24 | 4.12 | 65 | May 25 | 4.02 | 44 |
| February 27 | 4.08 | 70 | June 1 | 4.40 | 187 |
| March 2 | 4.11 | 67 | June 10 | 4.00 | 74 |
| March 7 | 4.11 | 52 | June 17 | 3.92 | 32 |
| March 9 | 4.10 | 56 | June 24 | 4.05 | 38 |
| March 12 | 7.80 | 9,260 | June 29 | 4.16 | 29 |
| March 18 | 4.15 | 1,620 | July 5 | 4.24 | 27 |
| March 20 | 4.11 | 828 | July 13 | 4.31 | 28 |
| March 23 | 4.45 | 552 | July 19 | 4.32 | 33 |
| March 25 | 6.25 | 4,530 | July 22 | 4.36 | 33 |
| March 26 | 5.60 | 5,570 | July 29 | 4.41 | 31 |
| March 27[a] | 4.90 | 2,100 | July 31[b] | 4.39 | 22 |
| March 27[a] | 4.80 | 1,880 | November 12[c] | | 41 |

[a] Measured by Burrage and Leahy. [b] Measured by W. B. Clapp. [c] Measured by W. F. Martin.

## SOUTHERN PACIFIC OCEAN DRAINAGE.

### GENERAL FEATURES.

The Southern Pacific Ocean drainage includes those streams south of San Francisco Bay whose waters, in times of flood at least, reach the Pacific Ocean.

### SAN DIEGO BAY DRAINAGE BASIN.

#### DESCRIPTION OF BASIN.

The principal streams tributary to San Diego Bay are Tia Juana, Sweetwater, and San Diego rivers.

The Tia Juana is not measured at any regular station, but stations are maintained on Cottonwood Creek, which discharges into it about 30 miles east of San Diego city, and on Pine Creek, a branch of Cottonwood, and stations are also maintained on Sweetwater and San Diego rivers.

Measurements in this basin are made for use in connection with the construction of reservoirs for irrigation purposes.

#### COTTONWOOD CREEK NEAR JAMUL, CAL.

Cottonwood Creek rises on the west side of the San Jacinto Mountains, in the southwestern part of San Diego County, at an elevation of about 5,000 feet, and flows in a southwesterly direction, discharging

into the Tia Juana River just above the California-Mexico boundary line and about 30 miles east of San Diego city. Its drainage basin is rough and broken, with numerous hills and gorges and only a few small valleys. A scrubby timber growth throughout the basin consists mainly of oak, with some sycamore and cottonwood. The annual precipitation varies from 10 to 30 inches and is mainly in the form of rain. The light snowfall on the higher parts of the area melts rapidly, increasing the torrential nature of the run-off. There are several dam sites in this basin, at least two of which have been utilized. The rock formation through which the creek flows is a loose granite with a good soil covering.

The station was established December 14, 1905. It is located at the Barrett dam site, about 8 miles north of the California-Mexico boundary line, and is reached by driving from San Diego to Jamul ranch house, about 20 miles east of San Diego, then driving to the dam site, about 15 miles farther east, making the total distance from San Diego about 35 miles.

The measuring section was first located on the broad crest of the concrete foundation wall of the original Barrett dam, but some time in the late summer the gage was removed on account of constructive operations in connection with the new dam. Above this section the channel had filled in so that the sand was level with the crest of the wall, while on the lower side the water had a free fall of 30 feet. Vertical timber walls had been built up at each end of the dam, so that the width of the channel at all stages was 70 feet. The grade above the section was heavy, so that very high velocities prevailed in flood stages. A new section has been selected a few hundred feet above the old one, at the foundation of the new dam. At low stages the flow is restricted to a rectangular wooden flume through the foundation wall, but at higher stages the flow is over the entire length of the foundation wall.

Discharge measurements are usually made by wading, except in high stages, when only float measurements can be made, owing to the torrential nature of the stream. In low stages a section suitable for wading is always used. There is no cable and car equipment at this station.

The old gage was a 2 by 4 inch pine scantling, graduated to feet and tenths with black stripes and staples and attached in a vertical position to the timber wall on the left bank. The new gage is in two sections, a low-water gage attached to the foundation wall near the wooden flume and a high-water gage fastened to bowlders on the left bank. During 1906 the gage was read twice a day by Joe Hooker. No permanent bench mark for reference has yet been established.

*Discharge measurements of Cottonwood Creek near Jamul, Cal., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| November 18 | W. B. Clapp | 2.7 | 0.5 | | 0.5 |
| December 14 | C. H. Lee | 5 | 1.6 | 0.05 | 1.1 |
| 1906. | | | | | |
| January 5 | W. V. Hardy | 6 | 2.9 | 0.10 | 3.5 |
| January 19 | do | 16 | 6.7 | 0.21 | 12.4 |
| January 19 | do | 22 | 12.5 | 0.30 | 32 |
| January 20 | do | 70 | 20 | 0.40 | 39 |
| January 20 | do | 70 | 28 | 0.50 | 63 |
| January 20 | do | 70 | 29 | 0.55 | 76 |
| February 3 | do | 10 | 3 | 0.05 | 4.1 |
| February 14 | do | 20 | 8.7 | 0.23 | 15.5 |
| March 11 | do | 21 | 7.7 | 0.12 | 13.2 |
| March 12 | do | 70 | 71 | 1.21 | 383 |
| March 13 [a] | Joe Hooker | 70 | 154 | 2.20 | 644 |
| March 16 [a] | do | 70 | 57 | 0.82 | 150 |
| March 21 [a] | do | 70 | 41 | 0.58 | 90 |
| March 24 [a] | do | 70 | 420 | 6.00 | 5,330 |
| March 25 [a] | do | 70 | 455 | 6.50 | 4,100 |
| March 31 [a] | do | 70 | 77 | 1.10 | 416 |
| April 7 [a] | do | 70 | 57 | 0.81 | 239 |
| April 19 | W. V. Hardy | 70 | 37 | 0.59 | 116 |
| May 8 | do | 70 | 27 | 0.40 | 76 |
| June 22 | C. H. Lee | 36 | 9.9 | 0.28 | 14.2 |
| October 5 | W. F. Martin | 2.8 | 0.8 | | 1.0 |
| November 27 | W. V. Hardy | 6 | 5.4 | [b] 0.90 | 32 |
| December 15 | do | 6 | 6 | [b] 2.00 | 40 |

[a] Measured by floats. [b] New gage.

*Monthly discharge of Cottonwood Creek near Jamul, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 59 | 2.0 | 15.5 | 953 |
| February | 100 | 7.0 | 24.1 | 1,340 |
| March | 5,800 | 5.0 | 594 | 35,500 |
| April | 350 | 93 | 176 | 10,500 |
| May | 93 | 20 | 54.9 | 3,380 |
| June | 55 | 20 | 30.5 | 1,820 |
| July | 93 | 2.0 | 12.0 | 738 |
| August | 51 | .9 | 6.0 | 369 |
| September | 4.8 | .8 | 1.3 | 77 |
| October | 7.1 | .9 | 3.0 | 184 |
| November | 33 | 7.6 | 20.4 | 1,210 |
| December | 375 | 30 | 80.8 | 4,970 |
| The year | 5,800 | .8 | 84.9 | 62,000 |

NOTE.—Discharges were obtained by the indirect method for shifting channels. Values are fair.

## PINE VALLEY CREEK NEAR JAMUL, CAL.

Pine Valley Creek flows in a southerly direction and enters Cottonwood Creek about 1 mile north of Barrett's dam. Its drainage area is about half of the total drainage area of Cottonwood Creek above Barrett's dam. The gaging station is located a few hundred feet above the confluence of the two creeks and was established in January, 1906. It is reached in connection with the Cottonwood station by driving from San Diego.

The channel at the station is composed of shifting sand, and is straight for about 200 feet above and 250 feet below the point of measurement. The right bank is high and rocky and not subject to overflow, while the left bank is liable to overflow in very high stages,

forming two channels. In almost all stages measurements can be made by wading, but two wires have been stretched across the channel 50 feet apart for convenience in float measurements. There is no cable and car.

The gage, which during 1906 was read twice a day by Joe Hooker, is a piece of 2 by 6 inch pine painted white and graduated to feet and tenths with staples. It is fastened to a small tree in a vertical position and the graduations run from 3 to 9.9 feet. The initial point for soundings is the top of a bowlder on the right bank marked with a ring of white paint. The top of this bowlder is also taken as a bench mark, with assumed elevation 1,600 feet. The zero of gage is 13.16 feet below, or at elevation 1,586.84.

*Discharge measurements of Pine Valley Creek near Jamul, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 5 | W. V. Hardy | 6 | 1.5 | ..... | 1.8 |
| January 19 | do | 14 | 7.2 | 3.10 | 14.4 |
| January 19 | do | 34 | 12.3 | 3.20 | 17.6 |
| January 20 | do | 41 | 19.4 | 3.45 | 41 |
| February 3 | do | 8 | 2.8 | 2.94 | 4 |
| February 15 | do | 42 | 13.1 | 3.12 | 20 |
| March 11 | do | 12 | 5.4 | 3.00 | 8.2 |
| April 19 | do | 46 | 23 | 4.50 | 57 |
| May 8 | do | 47 | 16 | 4.40 | 32 |
| June 22 | C. H. Lee | 17 | 4.8 | 4.20 | 7.7 |
| October 5 | W. F. Martin | 2.8 | 0.21 | 4.00 | 0.24 |
| November 27 | W. V. Hardy | 11 | 4.1 | 4.21 | 6.7 |
| December 15 | do | 19 | 6.7 | 4.30 | 14.6 |

*Daily gage height, in feet, of Pine Valley Creek near Jamul, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 3.00 | 3.00 | 4.90 | 4.55 | 4.40 | 4.12 | 4.02 | 3.95 | 3.94 | 4.10 | 4.15 |
| 2 | ..... | 2.95 | 3.00 | 4.90 | 4.55 | 4.35 | 4.12 | 4.01 | 3.95 | 4.03 | 4.05 | 4.20 |
| 3 | ..... | 2.95 | 2.98 | 4.75 | 4.50 | 4.35 | 4.11 | 4.01 | 3.95 | 4.10 | 4.05 | 4.20 |
| 4 | ..... | 2.95 | 3.00 | 4.75 | 4.50 | 4.30 | 4.12 | 4.00 | 3.95 | 3.98 | 4.00 | 4.20 |
| 5 | ..... | 2.96 | 3.04 | 4.80 | 4.55 | 4.30 | 4.13 | 3.95 | 3.94 | 3.80 | 4.10 | 4.20 |
| 6 | ..... | 3.24 | 2.98 | 4.75 | 4.50 | 4.30 | 4.10 | 3.93 | 3.94 | 3.55 | 4.10 | 4.25 |
| 7 | ..... | 3.15 | 2.92 | 4.80 | 4.50 | 4.30 | 4.20 | 3.80 | 4.00 | 3.60 | 4.10 | 4.25 |
| 8 | ..... | 3.07 | 2.93 | 4.70 | 4.40 | 4.30 | 4.20 | 3.79 | 4.00 | 3.70 | 4.10 | 4.25 |
| 9 | ..... | 3.09 | 2.92 | 4.65 | 4.40 | 4.30 | 4.22 | 3.76 | 3.98 | 3.75 | 4.10 | 4.25 |
| 10 | ..... | 3.01 | 2.95 | 4.65 | 4.40 | 4.30 | 4.20 | 3.65 | 3.98 | 3.80 | 4.10 | 4.20 |
| 11 | ..... | 3.11 | 2.97 | 4.60 | 4.35 | 4.25 | 4.17 | 3.60 | 4.00 | 4.00 | 4.05 | 4.25 |
| 12 | ..... | 3.01 | 4.35 | 4.55 | 4.40 | 4.20 | 4.15 | 3.55 | 4.00 | 4.00 | 4.10 | 4.30 |
| 13 | ..... | 3.01 | 5.00 | 4.60 | 4.40 | 4.20 | 4.12 | 3.48 | 4.09 | 4.05 | 4.10 | 4.45 |
| 14 | ..... | 3.09 | 4.03 | 4.55 | 4.40 | 4.20 | 4.12 | 3.40 | 4.08 | 4.05 | 4.05 | 4.45 |
| 15 | ..... | 4.02 | 3.70 | 4.55 | 4.40 | 4.20 | 4.10 | 3.37 | 4.12 | 3.95 | 4.10 | 4.30 |
| 16 | ..... | 3.60 | 4.04 | 4.50 | 4.40 | 4.20 | 4.11 | 3.00 | 4.02 | 3.95 | 4.10 | 4.30 |
| 17 | ..... | 3.40 | 3.95 | 4.50 | 4.35 | 4.20 | 4.10 | 2.70 | 4.05 | 4.00 | 4.10 | 4.20 |
| 18 | 3.00 | 3.30 | 3.60 | 4.50 | 4.35 | 4.20 | 4.10 | 4.40 | 3.96 | 4.00 | 4.10 | 4.20 |
| 19 | 3.20 | 3.28 | 3.50 | 4.50 | 4.30 | 4.15 | 4.11 | 4.40 | 4.05 | 4.10 | 4.05 | 4.30 |
| 20 | 3.45 | 3.20 | 3.38 | 4.50 | 4.30 | 4.15 | 4.10 | 4.20 | 4.03 | 4.05 | 4.05 | 4.20 |
| 21 | 3.25 | 3.21 | 3.31 | 4.45 | 4.30 | 4.10 | 4.07 | 4.20 | 3.98 | 4.10 | 4.10 | 4.20 |
| 22 | 3.20 | 3.22 | 3.35 | 4.45 | 4.40 | 4.20 | 4.05 | 4.20 | 4.02 | 4.10 | 4.10 | 4.15 |
| 23 | 3.18 | 3.19 | 3.30 | 4.50 | 4.40 | 4.15 | 4.06 | 4.20 | 3.91 | 4.05 | 4.20 | 4.20 |
| 24 | 3.10 | 3.08 | ..... | 4.50 | 4.40 | 4.15 | 4.06 | 4.19 | 4.01 | 4.10 | 4.20 | 4.20 |
| 25 | 3.08 | 3.01 | ..... | 4.50 | 4.40 | 4.15 | 4.05 | 4.18 | 4.03 | 4.05 | 4.20 | 4.20 |
| 26 | 3.05 | 2.96 | ..... | 4.50 | 4.50 | 4.15 | 4.05 | 4.18 | 4.00 | 4.00 | 4.20 | 4.20 |
| 27 | 3.03 | 2.94 | ..... | 4.50 | 4.45 | 4.15 | 4.05 | 4.18 | 4.04 | 4.10 | 4.20 | 4.30 |
| 28 | 3.03 | 2.97 | 5.20 | 4.65 | 4.50 | 4.20 | 4.04 | 4.16 | 3.98 | 4.10 | 4.20 | 4.70 |
| 29 | 3.03 | ..... | 4.82 | 4.75 | 4.50 | 4.15 | 4.03 | 4.10 | 3.92 | 4.10 | 4.10 | 4.60 |
| 30 | 3.03 | ..... | 4.80 | 4.65 | 4.40 | 4.15 | 4.02 | 4.00 | 4.00 | 4.00 | 4.15 | 4.50 |
| 31 | 3.03 | ..... | 5.00 | ..... | 4.40 | ..... | 4.02 | 4.00 | ..... | 4.10 | ..... | 4.50 |

*Monthly discharge of Pine Valley Creek near Jamul, Cal., for 1906.*

| Month. | Discharge in second-feet | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 41 | 1 | 10.4 | 640 |
| February | 75 | 5 | 19.4 | 1,080 |
| March | 1,500 | 3 | 156 | 9,590 |
| April | 150 | 44 | 89.6 | 5,330 |
| May | 71 | 15 | 39.4 | 2,420 |
| June | 32 | 1.8 | 9.8 | 583 |
| July | 8.2 | .6 | 2.6 | 160 |
| August | 32 | 0.0 | 4.0 | 246 |
| September | 2.7 | .2 | .6 | 36 |
| October | 1.8 | 0.0 | .8 | 49 |
| November | 6.5 | .3 | 2.6 | 155 |
| December | 114 | 4.2 | 20.1 | 1,240 |
| The year | 1,500 | 0.0 | 29.6 | 21,500 |

NOTE.—Discharges were obtained by the indirect method for shifting channels. Values are approximate.

## SWEETWATER RIVER NEAR DESCANSO, CAL.

Sweetwater River heads on the west slope of San Jacinto Mountains in the west-central portion of San Diego County and flows in a southwesterly direction, discharging into San Diego Bay near National City. The highest parts of the basin are found about 2 miles east of Cuyamaca, at an elevation of more than 5,000 feet. This basin consists of a loose granite formation, and the topography is very much broken with numerous canyons, mountain peaks, and small valleys. There is a scrubby timber growth on the highlands, consisting mainly of oak brush. The annual precipitation in the basin varies from 5 to 20 inches near National City, but increases on the higher elevations up to from 30 to 60 inches near Cuyamaca, where 20 to 30 inches of snowfall occur in some years. The run-off in surface flow is heavy in the spring, but during the summer and fall the surface flow entirely disappears in the sands of the lower reaches.

This station was established December 9, 1905. It is located on the Ellis ranch, about 1 mile south of Descanso post-office, and is reached by stage from Lakeside. This station is at an elevation of 3,300 feet and has a drainage area of only 40 square miles, which is almost rectangular in outline, being about 10 miles long north and south and 4 miles wide.

The station is equipped with cable and car, but measurements can always be made by wading, except at very high stages. The bed of the stream is composed of sand and gravel, with isolated bowlders, and is subject to more or less change. Both banks may be overflowed at exceptionally high stages. The channel is straight for 150 feet above and 300 feet below the station. A dense growth of willows on each bank has been cleared away for 20 feet above and below the cable. The grade is heavy above the section, so that high velocities are encountered at the highest stage, when only float velocities can be taken.

The gage consists of a 2 by 6 inch pine timber painted white and graduated to feet and tenths. It is bolted to granite bowlders on the left bank, and is in three sections—two for low water and one for high water. The graduations extend from 2.8 to 10.7 feet.

The initial point for soundings is the head of a big nail driven in the base of the oak tree anchorage on the right bank. The bench mark is the highest point on the bowlder to which the lowest low-water gage is fastened, and is 20 feet upstream from station 60 of cable. It is marked 0.0 in white paint and its elevation is assumed to be 3,300 feet. The zero of the gage is 5 feet below the bench mark, or at an elevation of 3,295.0.

During 1906 the gage was read twice a day by C. H. Ellis.

*Discharge measurements of Sweetwater River near Descanso, Cal., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| September 11 [a] | D. W. Murphy | | | | 0.4 |
| November 21 | C. H. Lee | 3 | 0.9 | 3.54 | 1.1 |
| December 10 | do | 6 | 1.9 | 3.62 | 2.5 |
| 1906. | | | | | |
| January 6 | W. V. Hardy | 6.5 | 1.7 | 3.62 | 2.7 |
| January 23 | do | 11 | 4.9 | 3.79 | 9.3 |
| February 4 | do | 10 | 3.7 | 3.68 | 4.8 |
| February 15 | do | 40 | 41 | 4.60 | 115 |
| February 16 | do | 38 | 35 | 4.50 | 96 |
| February 16 | do | 36 | 30 | 4.40 | 75 |
| February 16 | do | 36 | 27 | 4.30 | 62 |
| February 16 | do | 34 | 22 | 4.20 | 51 |
| February 16 | do | 32 | 20 | 4.10 | 46 |
| February 17 | do | 31 | 15.9 | 4.00 | 32 |
| February 19 | do | 30 | 12.4 | 3.90 | 20 |
| March 10 | do | 11.7 | 5.1 | 3.88 | 10.7 |
| April 5 | do | 40 | 32 | 4.85 | 81 |
| April 6 | do | 41 | 33 | 4.65 | 74 |
| April 18 | do | 36 | 14 | 4.27 | 37 |
| April 20 | do | 35 | 13 | 4.20 | 35 |
| May 8 | do | 31 | 10.4 | 4.05 | 24 |
| June 19 | C. H. Lee | 12 | 2.6 | 3.60 | 4.3 |
| August 7 | R. S. Hawley | 2.5 | 0.8 | 3.16 | 1.1 |
| October 9 | W. F. Martin | 2 | 1.2 | 3.15 | 1.1 |
| November 28 | W. V. Hardy | 6 | 3.2 | 3.20 | 4.4 |
| December 13 | do | 12 | 6.8 | 3.48 | 12.7 |

[a] Weir measurement.

*Daily gage height, in feet, of Sweetwater River near Descanso, Cal., for 1905–6.*

| Day. | Nov. | Dec. | Day. | Nov. | Dec. | Day. | Nov. | Dec. | Day. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905. | | | 8 | | 3.58 | 16 | | 3.60 | 24 | 3.54 | [a]3.62 |
| 1 | | 3.69 | 9 | | 3.58 | 17 | | 3.60 | 25 | 3.53 | 3.64 |
| 2 | | 3.64 | 10 | | 3.64 | 18 | | 3.67 | 26 | 3.54 | 3.65 |
| 3 | | 3.61 | 11 | | 3.68 | 19 | | 3.66 | 27 | 3.84 | 3.65 |
| 4 | | 3.60 | 12 | | 3.69 | 20 | | 3.66 | 28 | 3.84 | 3.65 |
| 5 | | 3.60 | 13 | | 3.65 | 21 | 3.53 | 3.78 | 29 | 3.71 | 3.69 |
| 6 | | 3.58 | 14 | | 3.60 | 22 | 3.54 | 3.70 | 30 | 3.70 | 3.66 |
| 7 | | 3.58 | 15 | | 3.60 | 23 | 3.54 | 3.62 | 31 | | 3.72 |

[a] Estimated.

*Daily gage height, in feet, of Sweetwater River near Descanso, Cal., for 1905–6*—Cont'd.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906. | | | | | | | | | | | | |
| 1 | 3.7 | 3.65 | 4.0 | 4.8 | 4.2 | 3.9 | 3.45 | 3.2 | 3.3 | 3.15 | a 3.2 | 3.2 |
| 2 | 3.65 | 3.65 | 3.95 | 4.7 | 4.15 | 3.85 | 3.4 | 3.2 | 3.3 | 3.15 | a 3.2 | 3.25 |
| 3 | 3.7 | 3.65 | 3.9 | 4.7 | 4.1 | 3.85 | 3.4 | 3.2 | 3.3 | 3.15 | a 3.2 | 3.25 |
| 4 | 3.7 | 3.7 | 4.0 | 4.6 | 4.1 | 3.85 | 3.4 | 3.2 | 3.3 | 3.15 | a 3.2 | 3.3 |
| 5 | 3.65 | 3.85 | 3.95 | 4.7 | 4.2 | 3.85 | 3.4 | 3.2 | 3.3 | 3.1 | 3.2 | 3.25 |
| 6 | 3.65 | 3.95 | 3.9 | 4.7 | 4.15 | 3.85 | 3.4 | 3.2 | 3.3 | 3.1 | 3.2 | 3.25 |
| 7 | 3.6 | 3.9 | 3.85 | 4.65 | 4.15 | 3.8 | 3.4 | 3.2 | 3.3 | 3.1 | 3.2 | 3.2 |
| 8 | 3.6 | 3.8 | 3.85 | 4.6 | 4.1 | 3.8 | 3.4 | 3.2 | 3.3 | 3.1 | 3.2 | 3.2 |
| 9 | 3.6 | 3.8 | 3.85 | 4.6 | 4.25 | 3.75 | 3.4 | 3.2 | 3.3 | 3.1 | 3.2 | 3.2 |
| 10 | 3.6 | 3.85 | 3.85 | 4.5 | 4.0 | 3.7 | 3.4 | 3.15 | 3.25 | 3.1 | 3.15 | a 3.2 |
| 11 | 3.6 | 3.95 | 3.9 | 4.45 | 4.0 | 3.7 | 3.35 | 3.15 | 3.25 | 3.1 | 3.15 | a 3.4 |
| 12 | 3.6 | 3.9 | 4.95 | 4.4 | 4.1 | 3.7 | 3.35 | a 3.15 | 3.25 | 3.1 | 3.15 | 3.9 |
| 13 | 3.65 | 3.9 | 5.05 | 4.4 | 4.0 | 3.7 | 3.35 | 3.15 | 3.25 | 3.1 | 3.15 | 3.45 |
| 14 | 3.75 | 3.9 | 4.5 | 4.35 | 4.0 | a 3.65 | 3.4 | 3.15 | 3.3 | 3.1 | 3.2 | 3.3 |
| 15 | 3.7 | 4.45 | 4.4 | 4.35 | 3.95 | a 3.65 | 3.4 | 3.15 | 3.65 | 3.1 | a 3.2 | 3.2 |
| 16 | 3.7 | 4.2 | 4.65 | 4.3 | 3.9 | a 3.6 | 3.35 | 3.15 | 3.45 | 3.1 | a 3.15 | 3.2 |
| 17 | 3.65 | 4.1 | 5.05 | 4.3 | 3.9 | 3.6 | 3.35 | 3.3 | 3.25 | 3.15 | a 3.15 | 3.2 |
| 18 | 3.65 | 3.95 | 4.65 | 4.25 | 3.9 | 3.6 | 3.3 | 3.6 | 3.2 | 3.15 | 3.15 | 3.2 |
| 19 | 4.05 | 3.9 | 4.5 | 4.25 | 3.9 | 3.6 | 3.3 | 3.6 | 3.15 | 3.15 | 3.15 | 3.2 |
| 20 | 4.15 | 3.85 | 4.4 | 4.2 | 3.9 | 3.6 | 3.3 | 3.5 | 3.15 | 3.15 | 3.15 | 3.2 |
| 21 | 3.9 | 3.95 | 4.35 | 4.2 | 3.9 | 3.55 | 3.3 | 3.45 | 3.15 | 3.15 | 3.15 | 3.2 |
| 22 | 3.85 | 4.0 | 4.45 | 4.15 | 3.85 | 3.55 | 3.3 | 3.4 | 3.1 | 3.15 | 3.4 | 3.2 |
| 23 | 3.8 | 3.95 | 4.35 | 4.1 | 3.9 | 3.55 | 3.3 | 3.4 | 3.1 | 3.2 | 3.45 | 3.2 |
| 24 | 3.75 | 3.9 | 7.35 | 4.15 | 3.9 | 3.55 | 3.3 | 3.45 | 3.15 | 3.2 | 3.35 | 3.2 |
| 25 | 3.75 | 3.85 | 6.8 | 4.15 | 3.9 | 3.5 | 3.35 | 3.35 | 3.15 | 3.2 | 3.3 | 3.2 |
| 26 | 3.75 | 3.85 | 6.6 | 4.1 | 4.05 | 3.55 | 3.35 | 3.35 | 3.15 | 3.2 | 3.3 | 3.45 |
| 27 | 3.7 | 3.85 | 5.6 | 4.1 | 4.0 | 3.6 | 3.3 | 3.35 | 3.1 | 3.2 | 3.35 | 3.7 |
| 28 | 3.7 | 3.95 | 5.2 | 4.4 | 4.2 | 3.55 | 3.25 | 3.35 | 3.1 | 3.25 | 3.2 | 4.5 |
| 29 | 3.7 | ..... | 4.85 | 4.4 | 4.0 | 3.5 | 3.25 | 3.35 | 3.15 | 3.25 | 3.2 | 3.8 |
| 30 | 3.7 | ..... | 4.7 | 4.25 | 3.95 | 3.45 | 3.2 | 3.35 | 3.2 | 3.2 | 3.2 | 3.5 |
| 31 | 3.7 | ..... | 4.7 | ..... | 3.9 | ..... | 3.2 | 3.3 | ..... | a 3.2 | ..... | 3.5 |

a Estimated.

*Monthly discharge of Sweetwater River near Descanso, Cal., for 1906.*

[Drainage area, 40 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 44 | 2.0 | 8.7 | 534 | 0.217 | 0.25 |
| February | 86 | 4.2 | 22.3 | 1,240 | .558 | .58 |
| March | 1,250 | 17.0 | 180 | 11,100 | 4.50 | 5.19 |
| April | 84 | 26 | 48.5 | 2,890 | 1.21 | 1.35 |
| May | 36 | 13 | 21.6 | 1,330 | .540 | .62 |
| June | 15 | 2.6 | 7.0 | 418 | .176 | .20 |
| July | 2.6 | 1.2 | 1.8 | 112 | .046 | .05 |
| August | 4.6 | 1.1 | 1.8 | 108 | .044 | .05 |
| September | 5.8 | 1.0 | 1.5 | 90 | .038 | .04 |
| October | 1.4 | 1.0 | 1.1 | 68 | .028 | .03 |
| November | 12 | 1.1 | 3.0 | 177 | .074 | .08 |
| December | 66 | 4.4 | 10.1 | 121 | .252 | .29 |
| The year | 1,250 | 1.0 | 25.6 | 18,200 | .640 | 8.73 |

NOTE.—Discharges were obtained from several rating tables covering short periods of time. Values are fair.

## SAN DIEGO RIVER NEAR LAKESIDE, CAL.

San Diego River has its headwaters on the west side of San Jacinto Mountains in the western portion of San Diego County, and flows in a southwesterly direction, discharging into the Pacific Ocean just north of San Diego city. This drainage basin lies just north of the Sweetwater drainage basin and south of the Santa Ysabel basin.

The extreme headwaters reach almost to the Santa Ysabel Indian Reservation on the north, and include the Cuyamaca reservoir. The topography of the basin is very rough, owing to numerous narrow canyons with small streams and mountain peaks, some of which have an elevation of 6,000 feet. The discharge is heavy in the spring and is of a torrential nature, but during the summer and fall there is no surface flow in the lower portion of the basin, the water disappearing in the sands 30 or 40 miles above San Diego city. The annual precipitation ranges from 10 to 20 inches near San Diego and from 20 to 30 or even 50 inches in the mountains, where some of it appears as snow. The formation is a loose granite and there is only a scrubby timber growth.

This station was established in December, 1905. It is located about 1 mile northwest of the Lakeside hotel and about three-fourths mile above the railroad station, on the road from Lakeside to Padre Barona Valley. It is 23 miles northeast of San Diego and is reached by the San Diego, Cuyamaca and Eastern Railway.

This station has a cable and car equipment, but, except in high stages, discharge measurements can always be made by wading. The bed of the stream is composed of a fine, shifting sand which supports no vegetation, and the channel is continually changing from side to side in low water. The left bank is high and rocky above the station and not liable to overflow, except below the measuring section. The right bank is composed of old river deposit and is subject to overflow above and below the station in very high stages. The channel is straight for 200 feet above and 250 feet below the station. The willow growth on right bank has been cleared away 20 feet above and below the cable. In low stages the quantity of water flowing on the surface depends on the saturation of the sand, and measurements will appear inconsistent, owing to the filling and scouring.

The gage consists of a 2 by 6 inch pine timber painted white and graduated to feet and tenths. It is on the left bank and is in two sections, a low and high water section, each bolted to granite bowlders.

The graduations extend from 2 to 7.8 feet.

The initial point for soundings is the head of a large nail on the left bank driven into a soft granite rock and painted yellow. 0. 0 in yellow paint is placed on the rock. A reference bench mark has been established on the top of the flat bowlder lying between the sycamore tree supporting the cable on the left bank and the bowlder used for an anchor. It is 8 feet downstream from station 20 of cable and is surrounded by a ring of white paint and has the assumed elevation of 400 feet marked on it. The zero of the gage is 7.77 feet below the bench mark, or at an elevation of 392.23 feet.

During 1906 the gage was read once a day by J. H. Lucas.

*Discharge measurements of San Diego River near Lakeside, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 9 | W. V. Hardy | 3 | 0.7 | 2.67 | 0.4 |
| January 24 | do | 25 | 8.3 | 3.04 | 12.5 |
| February 6 | do | 6 | 1.2 | 2.90 | 1.3 |
| February 12 | do | 53 | 24 | 3.20 | 42 |
| February 20 | do | 53 | 25 | 3.28 | 45 |
| February 22 | do | 56 | 42 | 3.54 | 100 |
| February 22 | do | 55 | 39 | 3.50 | 92 |
| February 22 | do | 54 | 30 | 3.40 | 67 |
| March 9 | do | 35 | 12 | 3.10 | 17 |
| March 13 | do | 63 | 123 | 4.50 | 714 |
| March 13 | do | 73 | 166 | 4.80 | 995 |
| March 14 | do | 63 | 75 | 4.10 | 280 |
| March 15 | do | 53 | 60 | 3.90 | 201 |
| April 7 | do | 63 | 75 | 4.50 | 403 |
| April 17 | do | 58 | 57 | 4.25 | 183 |
| April 21 | do | 57 | 39 | 4.15 | 98 |
| April 24 | do | 57 | 47 | 4.07 | 130 |
| April 30 | do | 56 | 46 | 4.25 | 186 |
| May 1 | do | 55 | 37 | 3.92 | 96 |
| May 9 | do | 56 | 30 | 3.86 | 62 |
| May 12 | do | 55 | 36 | 3.94 | 89 |
| June 20 | C. H. Lee | 16 | 2.6 | 3.45 | 2.8 |
| August 8 | R. S. Hawley | 2 | 0.4 | 3.39 | 0.3 |
| December 19 | W. V. Hardy | ..... | ..... | 3.30 | [a] 1.0 |

[a] Estimated, water too shallow to measure.

*Daily gage height, in feet, of San Diego River near Lakeside, Cal., for 1905–6.*

| Day. | 1905. | 1906. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dec. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Dec. |
| 1 | ..... | 2.66 | 2.90 | 3.32 | 4.9 | 4.2 | 3.8 | 3.45 | 3.4 | 3.35 | ..... |
| 2 | ..... | 2.66 | 2.91 | 3.26 | 4.75 | 4.15 | 3.75 | 3.45 | 3.4 | 3.35 | ..... |
| 3 | 2.60 | 2.66 | 2.91 | 3.20 | 4.65 | 4.0 | 3.75 | 3.45 | 3.4 | 3.35 | ..... |
| 4 | 2.60 | 2.67 | 2.91 | 3.20 | 4.6 | 3.95 | 3.75 | 3.45 | 3.4 | 3.35 | 3.35 |
| 5 | 2.60 | 2.68 | 2.92 | 3.28 | 4.5 | 3.9 | 3.7 | 3.45 | 3.4 | 3.3 | 3.3 |
| 6 | 2.60 | 2.68 | 2.98 | 3.18 | 4.5 | 3.95 | 3.7 | 3.45 | 3.4 | 3.3 | 3.3 |
| 7 | 2.60 | 2.68 | 3.02 | 3.12 | 4.5 | 3.9 | 3.7 | 3.4 | 3.4 | 3.3 | 3.3 |
| 8 | 2.60 | 2.68 | 3.12 | 3.11 | 4.55 | 3.85 | 3.65 | 3.4 | 3.4 | 3.3 | 3.3 |
| 9 | 2.60 | 2.68 | 3.02 | 3.10 | 4.45 | 3.85 | 3.65 | 3.4 | 3.4 | ..... | 3.35 |
| 10 | 2.62 | 2.67 | 3.12 | 3.08 | 4.4 | 3.8 | 3.65 | 3.4 | 3.4 | ..... | 3.35 |
| 11 | 2.62 | 2.66 | 3.15 | 3.08 | 4.35 | 3.85 | 3.6 | 3.4 | 3.4 | ..... | 3.3 |
| 12 | 2.63 | 2.65 | 3.18 | 3.20 | 4.35 | 3.85 | 3.6 | 3.4 | 3.4 | ..... | 3.4 |
| 13 | 2.63 | 2.65 | 3.18 | 4.50 | 4.25 | 3.9 | 3.6 | 3.4 | 3.4 | ..... | 3.6 |
| 14 | 2.63 | 2.66 | 3.20 | 4.10 | 4.2 | 3.85 | 3.6 | 3.4 | 3.4 | ..... | 3.4 |
| 15 | 2.63 | 2.66 | 3.28 | 3.96 | 4.2 | 3.8 | 3.55 | 3.4 | 3.4 | ..... | 3.3 |
| 16 | 2.63 | 2.67 | 4.00 | 4.05 | 4.2 | 3.8 | 3.55 | 3.4 | 3.4 | ..... | 3.3 |
| 17 | 2.63 | 2.67 | 3.64 | 4.65 | 4.2 | 3.8 | 3.5 | 3.4 | 3.4 | ..... | 3.3 |
| 18 | 2.64 | 2.67 | 3.48 | 4.36 | 4.2 | 3.75 | 3.5 | 3.4 | 3.4 | ..... | 3.3 |
| 19 | 2.64 | 2.74 | 3.41 | 4.25 | 4.15 | 3.8 | 3.5 | 3.4 | 3.4 | ..... | 3.3 |
| 20 | 2.66 | 3.91 | 3.28 | 3.94 | 4.1 | 3.75 | 3.5 | 3.4 | 3.4 | ..... | 3.3 |
| 21 | 2.66 | 3.40 | 3.26 | 3.88 | 4.15 | 3.75 | 3.5 | 3.4 | 3.4 | ..... | 3.35 |
| 22 | 2.66 | 3.35 | 3.54 | 3.84 | 4.1 | 3.75 | 3.5 | 3.4 | 3.4 | ..... | 3.3 |
| 23 | 2.65 | 3.68 | 3.48 | 3.90 | 4.1 | 3.75 | 3.5 | 3.4 | 3.4 | ..... | 3.3 |
| 24 | 2.65 | 3.07 | 3.38 | 5.58 | 4.05 | 3.75 | 3.5 | 3.4 | 3.4 | ..... | 3.3 |
| 25 | 2.65 | 3.00 | 3.24 | 7.00 | 4.05 | 3.75 | 3.45 | 3.4 | 3.4 | ..... | 3.3 |
| 26 | 2.65 | 2.96 | 3.22 | 6.88 | 4.0 | 3.75 | 3.45 | 3.4 | 3.35 | ..... | 3.35 |
| 27 | 2.67 | 2.92 | 3.18 | 5.80 | 4.0 | 3.85 | 3.45 | 3.4 | 3.35 | ..... | 3.4 |
| 28 | 2.67 | 2.92 | 3.18 | 5.42 | 4.05 | 3.75 | 3.5 | 3.4 | 3.35 | ..... | 3.8 |
| 29 | 2.67 | 2.92 | ..... | 5.14 | 4.2 | 3.95 | 3.5 | 3.4 | 3.35 | ..... | 4.15 |
| 30 | 2.66 | 2.91 | ..... | 4.96 | 4.25 | 3.85 | 3.5 | 3.4 | 3.35 | ..... | 3.8 |
| 31 | ..... | 2.90 | ..... | 4.99 | ..... | 3.8 | ..... | 3.4 | 3.35 | ..... | 3.75 |

NOTE.—The river was dry September 9 to December 3, 1906.

*Monthly discharge of San Diego River near Lakeside, Cal., for 1906.*

[Drainage area, 208 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 212 | 0.6 | 16.7 | 1,030 | .080 | .09 |
| February | 252 | 1.4 | 43.6 | 2,420 | .210 | .22 |
| March | 3,800 | 15 | 683 | 42,000 | 3.28 | 3.78 |
| April | 890 | 105 | 277 | 16,500 | 1.33 | 1.48 |
| May | 170 | 39 | 65.7 | 4,040 | .316 | .36 |
| June | 51 | 2.8 | 15.1 | 898 | .073 | .08 |
| July | 2.8 | .8 | 1.2 | 74 | .0058 | .007 |
| August | .8 | .4 | .6 | 37 | .0029 | .003 |
| September | .3 | 0 | .1 | 6 | .00048 | .0005 |
| October | 0 | 0 | 0 | 0 | .00 | .00 |
| November | 0 | 0 | 0 | 0 | .00 | .00 |
| December | 152 | 0 | 11.0 | 676 | .053 | .06 |
| The year | 3,800 | 0 | 92.8 | 67,700 | .446 | 6.08 |

NOTE.—Discharges were obtained by the indirect method for shifting channels. Values are fair.

## BERNARDO RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Bernardo River, or Santa Ysabel Creek, as it is known at its source, rises in the Volcan Range, on of the western ranges of San Jacinto Mountains, in the western part of San Diego County, at an elevation of 5,600 feet, and flows in a westerly direction through the San Pasqual Valley, below which it takes its true name and empties into the Pacific Ocean just north of the mouth of San Diego River. The upper part of this basin is on a loose granite formation and has a very rough topography, being cut up by numerous ravines in which small mountain streams flow continuously throughout the year. Below the mouth of the canyon, however, the surface flow of the Bernardo disappears in the sands of the San Pasqual Valley during the summer and fall.

The annual precipitation varies from 10 to 20 inches near San Diego, and from 20 to 30 or even 50 inches in the mountains, where some of it appears as snow. The heaviest discharge occurs in the spring, and is torrential in its nature. The drainage area above the mouth of the canyon where the gaging station is located is 128 square miles.

Measurements in this basin are useful for irrigation purposes.

### SANTA YSABEL CREEK NEAR ESCONDIDO, CAL.

This station was established in December, 1905. It is located at the mouth of the canyon and at the head of the San Pasqual Valley, about 13 miles east of the town of Escondido. It is reached by driving up through the San Pasqual Valley from Escondido to Pott's ranch, the station being directly east of and only a few hundred feet from the ranch house.

This station is equipped with a cable and car, but it is only during very high water that they need to be brought into use, as measurements can be made by wading, except in flood. The bed is composed of fine sand and is constantly changing. The channel is straight for 150 feet above and 100 feet below the cable, and both banks are high and rocky and not liable to overflow at any stage. The grade is heavy above the section, so that high velocities are encountered in flood stages, and in extremely high water only float velocities can be taken.

The gage is a 2 by 4 inch timber painted white and graduated into feet and tenths. It is in one section and is bolted in an inclined position to a large granite bowlder on the left bank. It is located 15 feet downstream from station 175 of the cable, and the graduations extend from 2 to 8 feet.

The initial point for soundings is the head of the eyebolt sulphured into the large granite bowlder on the right bank. A reference bench mark has been established on the highest point of the bowlder to which the gage is bolted, 11 feet downstream from station 180 of cable. A circle of white paint indicates the point, and the assumed elevation of 500 feet is marked on the bowlder. The zero of the gage is 11.66 feet below the bench mark, or at an elevation of 488.34 feet.

During 1906 the gage was read once a day by S. F. Potts.

*Discharge measurements of Santa Ysabel River near Escondido, Cal., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| November 21 | W. B. Clapp | 5 | 2.2 | | 4.5 |
| November 28 | C. H. Lee | 83 | 24 | 3.72 | 41 |
| December 21 | do | 24 | 7.2 | 3.55 | 10.4 |
| 1906. | | | | | |
| January 10 | W. V. Hardy | 8 | 2.5 | 3.56 | 4.2 |
| January 30 | do | 27 | 8.4 | 3.55 | 13.5 |
| February 8 | do | 38 | 12.8 | 3.57 | 17.8 |
| February 11 | do | 37 | 14.6 | 3.64 | 25 |
| February 22 | do | 64 | 21 | 3.70 | 44 |
| March 8 | do | 72 | 17.4 | 3.70 | 28 |
| March 15 | do | 62 | 45 | 3.75 | 158 |
| March 23 | do | 69 | 48 | 3.52 | 132 |
| March 26 | do | 119 | 654 | 4.00 | 5,300 |
| March 26 | do | 108 | 461 | 2.65 | 3,240 |
| March 26 | do | 108 | 362 | 2.00 | 2,040 |
| March 27 | do | 95 | 216 | 1.00 | 916 |
| March 27 | do | 94 | 177 | 0.85 | 870 |
| March 27 | do | 94 | 186 | 0.70 | 900 |
| March 28 | do | 83 | 143 | 0.50 | 713 |
| April 14 | do | 58 | 46 | 1.00 | 183 |
| April 25 | do | 52 | 38 | 1.45 | 116 |
| April 30 | do | 77 | 51 | 1.82 | 151 |
| May 12 | do | 106 | 32 | 2.18 | 88 |
| June 24 | C. H. Lee | 39 | 14 | 2.35 | 25 |
| August 10 | R. S. Hawley | 10 | 2.8 | 2.45 | 3.7 |
| October 3 [a] | W. F. Martin | | | 2.46 | 2.6 |
| November 30 | W. V. Hardy | 16 | 6.4 | 2.54 | 15 |
| December 7 | do | 15 | 6 | 2.64 | 10.8 |
| December 20 | do | 15 | 7 | 2.70 | 10 |

[a] Stream flowing in several channels.

*Daily gage height, in feet, of Santa Ysabel Creek near Escondido, Cal., for 1905–6.*

| Day. | 1905. | 1906. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dec. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
| 1 | ..... | 3.55 | 3.5 | 3.7 | 0.7 | 1.85 | 2.4 | 2.4 | 2.4 | 2.45 | 2.45 | 2.5 | 2.55 |
| 2 | ..... | 3.5 | 3.5 | 3.65 | 0.9 | 1.85 | 2.4 | 2.4 | 2.45 | 2.45 | 2.45 | 2.5 | 2.6 |
| 3 | ..... | 3.55 | 3.5 | 3.65 | 0.7 | 1.8 | 2.4 | 2.35 | 2.4 | 2.45 | 2.45 | 2.5 | 2.6 |
| 4 | ..... | 3.45 | 3.5 | 3.7 | 0.7 | 1.8 | 2.35 | 2.4 | (2.4) | 2.4 | 2.45 | 2.5 | 2.6 |
| 5 | ..... | 3.55 | 3.5 | 3.7 | 0.75 | 1.9 | 2.35 | 2.35 | 2.35 | 2.45 | 2.4 | 2.5 | 2.65 |
| 6 | ..... | 3.6 | 3.65 | 3.65 | 0.55 | 1.95 | 2.35 | 2.4 | 2.4 | 2.45 | 2.4 | 2.5 | 2.6 |
| 7 | ..... | 3.55 | 3.6 | 3.65 | 0.4 | 1.95 | 2.35 | 2.4 | 2.4 | 2.5 | 2.45 | 2.5 | 2.65 |
| 8 | ..... | 3.55 | 3.55 | 3.7 | 0.45 | 1.95 | 2.3 | 2.4 | 2.4 | 2.4 | 2.45 | 2.4 | 2.7 |
| 9 | ..... | 3.5 | 3.6 | 3.65 | 0.7 | 2.0 | 2.3 | 2.35 | 2.4 | 2.45 | 2.45 | 2.5 | 2.7 |
| 10 | ..... | 3.55 | 3.5 | 3.7 | 0.7 | 2.0 | 2.35 | 2.4 | 2.45 | 2.45 | 2.4 | 2.45 | 2.7 |
| 11 | ..... | 3.55 | 3.65 | 3.7 | 0.7 | 2.0 | 2.3 | 2.35 | 2.4 | 2.5 | 2.4 | 2.45 | 2.7 |
| 12 | ..... | 3.6 | 3.6 | 4.2 | 0.9 | 2.2 | 2.3 | 2.35 | 2.4 | 2.5 | 2.4 | 2.45 | 3.0 |
| 13 | ..... | 3.6 | 3.6 | 4.5 | 0.9 | 2.2 | 2.3 | 2.4 | 2.4 | 2.5 | 2.4 | 2.5 | 2.7 |
| 14 | ..... | 3.6 | 3.6 | 3.75 | 1.0 | 2.15 | 2.3 | 2.4 | 2.4 | 2.5 | 2.4 | a 2.5 | 2.7 |
| 15 | ..... | 3.6 | 3.9 | 3.7 | 1.0 | 2.1 | 2.35 | 2.4 | 2.45 | 2.5 | 2.4 | 2.55 | 2.7 |
| 16 | ..... | 3.5 | 3.9 | 3.8 | 1.05 | 2.2 | 2.3 | 2.4 | 2.45 | 2.5 | 2.45 | 2.5 | 2.7 |
| 17 | 3.46 | 3.5 | 3.75 | 4.25 | 1.15 | 2.2 | 2.3 | 2.4 | 2.45 | 2.5 | 2.45 | 2.5 | 2.7 |
| 18 | 3.47 | 3.6 | 3.7 | 3.9 | a 1.15 | 2.2 | 2.25 | 2.4 | 2.5 | 2.5 | 2.5 | 2.5 | 2.7 |
| 19 | 3.47 | 3.85 | 3.7 | 3.65 | a 1.15 | 2.2 | 2.3 | 2.4 | 2.55 | 2.45 | 2.5 | 2.5 | 2.7 |
| 20 | 3.48 | 3.75 | 3.7 | 3.6 | a 1.15 | 2.15 | 2.3 | 2.4 | 2.45 | 2.4 | 2.5 | 2.5 | 2.7 |
| 21 | 3.54 | 3.6 | 3.65 | 3.55 | a 1.2 | 2.2 | 2.3 | 2.4 | 2.45 | 2.4 | 2.5 | 2.55 | 2.7 |
| 22 | 3.52 | 3.5 | 3.7 | 3.6 | 1.2 | 2.25 | 2.25 | 2.4 | 2.4 | (2.4) | 2.5 | 2.55 | 2.7 |
| 23 | 3.50 | 3.5 | 3.7 | 3.5 | 1.3 | 2.25 | 2.2 | 2.4 | 2.4 | 2.45 | 2.5 | 2.6 | 2.75 |
| 24 | 3.48 | 3.55 | 3.65 | 6.3 | 1.4 | 2.3 | 2.3 | 2.4 | 2.45 | 2.45 | 2.5 | 2.5 | 2.7 |
| 25 | 3.49 | 3.5 | 3.65 | 3.5 | 1.45 | 2.3 | 2.4 | 2.45 | (2.4) | 2.5 | 2.5 | 2.55 | 2.7 |
| 26 | 3.48 | 3.5 | 3.65 | 1.9 | 1.4 | 2.45 | 2.3 | 2.45 | 2.4 | 2.5 | 2.5 | 2.6 | 2.8 |
| 27 | 3.47 | 3.55 | 3.65 | 0.9 | 1.5 | 2.35 | 2.35 | 2.4 | 2.4 | 2.5 | 2.5 | 2.55 | 2.8 |
| 28 | 3.48 | 3.55 | 3.7 | 0.6 | 1.6 | 2.25 | 2.4 | 2.4 | 2.45 | 2.5 | 2.5 | 2.55 | 2.75 |
| 29 | 3.51 | 3.55 | ..... | 0.8 | 1.7 | 2.3 | 2.35 | 2.4 | 2.4 | 2.5 | 2.5 | 2.55 | 2.7 |
| 30 | 3.52 | 3.55 | ..... | 0.9 | 1.6 | 2.4 | 2.3 | 2.4 | 2.4 | 2.45 | 2.5 | 2.55 | 2.75 |
| 31 | 3.55 | 3.55 | ..... | 0.9 | ..... | 2.4 | ..... | 2.4 | 2.45 | ..... | 2.5 | ..... | 2.85 |

a Estimated.

*Monthly discharge of Santa Ysabel Creek near Escondido, Cal., for 1906.*

[Drainage area, 128 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 83 | 2 | 11.4 | 701 | 0.089 | 0.10 |
| February | 95 | 8 | 30.5 | 1,690 | .238 | .25 |
| March | 8,000 | 29 | 633 | 38,900 | 4.94 | 5.70 |
| April | 400 | 102 | 221 | 13,200 | 1.73 | 1.93 |
| May | 90 | 35 | 69.7 | 4,290 | .545 | .63 |
| June | 35 | 23 | 28.4 | 1,690 | .222 | .25 |
| July | 30 | 5 | 12.4 | 762 | .097 | .11 |
| August | 6 | 4 | 4.2 | 258 | .033 | .04 |
| September | 4 | 3 | 3.1 | 184 | .024 | .03 |
| October | 7 | 3 | 4.7 | 289 | .037 | .04 |
| November | 15 | 6 | 9.6 | 571 | .075 | .08 |
| December | 21 | 11 | 12.4 | 762 | .097 | .11 |
| The year | 8,000 | 2 | 86.7 | 63,300 | .677 | 9.27 |

NOTE.—Discharges were obtained by the indirect method for shifting channels. Values are approximate.

## SAN LUIS REY RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

San Luis Rey River rises on the western slope of the Coast Range in the northern portion of San Diego County, and flows in a westerly direction, discharging its waters into the Pacific Ocean near the town

of Oceanside. It has numerous small tributaries, none of which have their sources at elevations above 5,000 feet. On the upper reaches of this stream the country is rolling, with several small valleys which are under cultivation, being used principally for the raising of grain and the pasturage of stock. At a point below what is known as the Warner's ranch reservoir site the river flows through a deep, narrow canyon with a heavy grade for a distance of about 10 miles. Below this point the grade is light, and the discharge is over a sandy and gravelly bed, where the water soon disappears, again rising in small quantities near the town of Pala, where the gaging station is located. Below the station it flows for a distance of about 25 miles on a light grade to the Pacific Ocean. There is a good soil covering throughout this basin, with a considerable growth of brush and grass, and with small areas of timber on the extreme higher elevations. The water is diverted at several points for irrigation, a considerable quantity being taken from the canyon above the gaging station and used in the vicinity of Escondido, which lies in an entirely separate drainage basin. This stream is torrential in its character, the discharge being very light except during the winter season, in times of heavy rainfall. The mean precipitation varies from 10 to 20 inches and falls principally in the form of rain, there being only a light fall of snow on the extreme higher elevations, which soon melts and only adds to the flood discharge.

### SAN LUIS REY RIVER NEAR PALA, CAL.

This station was established October 9, 1903. It is located at Sickler's mill, 4 miles above Pala, Cal. It is reached by driving from Fallbrook or Temecula, stations on the Southern California Railway, 18 and 13 miles distant, respectively. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 91, where are given also references to publications that contain data for previous years. The datum of the gage was lowered 4.66 feet November 13, 1906.

*Discharge measurements of San Luis Rey River near Pala, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 11 | W. V. Hardy | 10 | 6 | 0.60 | 9.0 |
| January 28 | do | 12 | 8.3 | 0.18 | 14.7 |
| February 9 | do | 12 | 5.5 | 0.13 | 10.4 |
| February 26 | do | 19 | 8.6 | 0.66 | 17.9 |
| March 4 | do | 22 | 14 | 1.02 | 38 |
| March 4 | do | 22 | 16 | 1.10 | 43 |
| March 5 | do | 22 | 18.8 | 1.20 | 48 |
| March 6 | do | 20 | 14. | 1.00 | 38 |
| March 7 | do | 20 | 12.4 | 0.93 | 32 |
| March 16 | do | 72 | 116 | 3.70 | 447 |
| March 17 | do | 89 | 287 | 5.30 | 1,540 |
| March 17 | do | 79 | 191 | 4.70 | 984 |
| March 17 | do | 72 | 156 | 4.30 | 811 |
| March 18 | do | 72 | 113 | 3.80 | 532 |
| March 19 | do | 67 | 105 | 2.70 | 367 |
| March 20 | do | 52 | 73 | 2.50 | 238 |
| March 21 | do | 52 | 64 | 2.40 | 182 |
| April 12 | do | 65 | 84 | 2.20 | 307 |
| April 26 | do | 57 | 37 | 1.52 | 119 |
| May 14 | do | 48 | 58 | 1.18 | 166 |
| June 27 | C. H. Lee | 33 | 15 | 0.61 | 28 |
| August 5 | R. S. Hawley | 11 | 3.8 | 0.30 | 5.9 |
| October 10 | W. F. Martin | 15 | 2.8 | ..... | 3.0 |
| November 13 | W. V. Hardy | 8 | 3.2 | [a]5.27 | 3.5 |
| December 5 | do | 25 | 9.0 | [a]5.55 | 13 |
| December 28 | do | 57 | 102 | [a]7.15 | 322 |

[a] By new gage.

*Daily gage height, in feet, of San Luis Rey River near Pala, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.75 | 0.1 | 0.8 | 3.35 | 1.6 | 1.1 | 0.5 | 0.5 | 0.2 | 0.2 | ..... | 5.6 |
| 2 | .7 | .1 | .8 | 2.9 | 1.5 | 1.1 | .5 | .5 | .2 | .2 | ..... | 5.6 |
| 3 | .7 | .9 | .8 | 2.55 | 1.4 | 1.1 | .5 | .5 | .2 | .2 | ..... | 5.55 |
| 4 | .7 | .9 | 1.0 | 2.5 | 1.4 | 1.1 | .5 | .5 | .2 | .2 | ..... | 5.55 |
| 5 | .7 | .15 | 1.2 | 2.75 | 1.5 | 1.1 | .5 | .5 | .2 | .2 | ..... | 5.55 |
| 6 | .7 | .2 | 1.0 | 3.0 | 1.45 | 1.05 | .5 | .5 | .2 | .2 | ..... | 5.55 |
| 7 | .7 | .3 | .95 | 3.0 | 1.4 | 1.0 | .5 | .25 | .2 | .2 | ..... | 5.5 |
| 8 | .7 | .3 | .7 | 3.05 | 1.3 | 1.0 | .5 | .3 | .2 | .2 | ..... | 5.5 |
| 9 | .65 | .25 | .6 | 2.6 | 1.3 | .9 | .5 | .25 | .2 | .2 | ..... | 5.5 |
| 10 | .65 | .2 | .65 | 2.6 | 1.3 | .85 | .5 | .25 | .2 | .2 | ..... | 5.45 |
| 11 | .6 | .65 | .65 | 2.45 | 1.25 | .8 | .5 | .3 | .2 | .2 | ..... | 5.4 |
| 12 | 6 | .5 | 5.0 | 2.2 | 1.55 | .7 | .5 | .25 | .2 | .2 | ..... | 7.8 |
| 13 | .6 | .4 | 6.55 | 2.15 | 1.4 | .7 | .5 | .2 | .2 | .2 | 5.25 | 7.2 |
| 14 | .7 | .4 | 3.55 | 2.15 | 1.2 | .65 | .5 | .2 | .2 | .2 | 5.25 | 6.5 |
| 15 | .7 | .8 | 2.3 | 2.15 | 1.15 | .6 | .5 | .2 | .5 | .2 | 5.25 | 5.8 |
| 16 | .7 | 2.65 | 2.85 | 2.05 | 1.1 | .6 | .5 | .2 | .35 | ..... | 5.25 | 5.8 |
| 17 | .65 | .85 | 4.8 | 2.05 | 1.05 | .85 | .5 | .2 | .2 | ..... | 5.25 | 5.7 |
| 18 | .65 | .95 | 3.65 | 1.95 | 1.0 | .8 | .5 | .8 | .2 | ..... | 5.25 | 5.65 |
| 19 | 1.0 | .85 | 2.95 | 1.95 | 1.0 | .7 | .5 | .7 | .2 | ..... | 5.25 | 5.6 |
| 20 | 2.6 | .75 | 2.5 | 1.85 | .95 | .6 | .5 | .6 | .2 | ..... | 5.25 | 5.55 |
| 21 | 1.2 | .9 | 2.4 | 1.8 | 1.0 | .6 | .5 | .5 | .2 | ..... | 5.25 | 5.55 |
| 22 | .9 | .95 | 2.5 | 1.75 | .9 | .65 | .5 | .3 | .2 | ..... | 5.5 | 5.5 |
| 23 | .6 | 1.0 | 2.5 | 1.75 | .9 | .6 | .5 | .25 | .2 | ..... | 5.65 | 5.5 |
| 24 | .3 | .95 | 10.0 | 1.65 | .9 | .55 | .5 | .25 | .2 | ..... | 5.6 | 5.45 |
| 25 | .3 | .9 | 7.0 | 1.6 | .9 | .5 | .5 | .2 | .2 | ..... | 5.6 | 5.4 |
| 26 | .25 | .6 | 7.25 | 1.5 | 1.25 | .5 | .5 | .2 | .2 | ..... | 5.6 | 5.8 |
| 27 | .2 | .6 | 4.6 | 1.45 | 1.5 | .5 | .5 | .2 | .2 | ..... | 5.7 | 6.6 |
| 28 | .18 | .9 | 4.4 | 1.7 | 1.7 | .5 | .5 | .2 | .2 | ..... | 5.6 | 6.7 |
| 29 | .15 | ..... | 4.1 | 1.7 | 1.5 | .5 | .5 | .2 | .2 | ..... | 5.6 | 6.8 |
| 30 | .15 | ..... | 3.35 | 1.6 | 1.3 | .5 | .5 | .2 | .2 | ..... | 5.6 | 6.6 |
| 31 | .15 | ..... | 4.0 | ..... | 1.25 | ..... | .5 | .2 | ..... | ..... | ..... | 6.7 |

NOTE.—Gage heights after November 13 are by the new gage, the datum of which is 4.66 feet below that of the old gage.

*Monthly discharge of San Luis Rey River near Pala for 1906.*

[Drainage area, 318 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 232 | 9 | 21.4 | 1,320 | 0.067 | 0.08 |
| February | 241 | 10 | 28.6 | 1,590 | .090 | .09 |
| March | 13,000 | 17 | 1,120 | 68,900 | 3.52 | 4.06 |
| April | 620 | 114 | 301 | 17,900 | .947 | 1.06 |
| May | 260 | 100 | 158 | 9,720 | .497 | .57 |
| June | 128 | 19 | 65.6 | 3,900 | .206 | .23 |
| July | 19 | 19 | 19.0 | 1,170 | .060 | .07 |
| August | 43 | 3 | 10.3 | 633 | .032 | .04 |
| September | 19 | 3 | 3.7 | 220 | .012 | .01 |
| October | 3 | 3 | 3.0 | 184 | .0094 | .01 |
| November | 28 | 3 | 8.3 | 494 | .026 | .03 |
| December | 550 | 9 | 79.3 | 4,880 | .249 | .29 |
| The year | 13,000 | 3 | 152 | 111,000 | .476 | 6.54 |

NOTE.—Discharges were obtained by the indirect method for shifting channels. Values are fair.

## SANTA MARGARITA RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Temecula Creek, as Santa Margarita River is known at its beginning, rises on the western slope of the San Jacinto Mountains in the northwestern part of San Diego County just north of the San Luis Rey drainage basin, flows north into Riverside County, then west about 15 miles to Temecula, where it flows southwest through Temecula Canyon into San Diego County and empties into the Pacific Ocean as Santa Margarita River. The highest elevation in the basin is about 5,500 feet on the divide between Temecula and San Luis Rey. Temecula Creek has few tributaries, and the topography is rather broken, though there are several small valleys in the upper reaches. The rock formation through which it flows is a loose granite with good soil covering, and there is considerable growth of small, scrubby timber. The annual precipitation varies from 10 to 30 inches and occurs almost entirely as rain. The discharge is quite heavy in the spring during the flood season, but is small during the rest of the year.

Measurements are useful in connection with irrigation.

### TEMECULA CREEK NEAR TEMECULA, CAL.

This station was established December 30, 1905. It is located about 1½ miles south of the town of Temecula at the bridge on the road from Temecula to Pala and Falbrook. It is reached by driving from Temecula.

The channel is straight for 500 feet above and 100 feet below. The bed is shifting sand and the channel is continually changing, being

usually in two channels at low water. Neither bank is liable to overflow at any stage.

During low water, discharge measurements are made by wading below the bridge. High-water measurements are made from the downstream side of the bridge.

The gage, which during 1906 was read once a day by Hugh McConville, is a 2 by 6 inch timber fastened to the downstream pier nearest to the right bank by two pieces of strap iron. It is in one vertical section, painted white, and graduated into feet and tenths. The graduations run from 0.0 to 10 feet. Marks 10 feet apart are put on the bridge rail in yellow paint for use in soundings. The bench mark is a nail in the base of a willow tree on the right bank of the river below the bridge; elevation, 8.13 feet above the zero of the gage.

*Discharge measurements of Temecula River near Temecula, Cal., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| November 14 | W. B. Clapp | 11 | 5.4 | 3.10 | 5.8 |
| December 30 | W. V. Hardy | 9 | 3.5 | 2.98 | 4.6 |
| 1906. | | | | | |
| January 12 | W. V. Hardy | 8 | 3.3 | 2.90 | 4.4 |
| January 29 | do | 8 | 4.0 | 2.94 | 4.9 |
| February 10 | do | 10 | 4.1 | 2.99 | 4.4 |
| February 24 | do | 16.5 | 7.7 | 3.20 | 3.3 |
| March 5 | do | 12 | 10.3 | 3.49 | 6.0 |
| March 6 | do | 12. | 9.3 | 3.42 | 5.4 |
| March 18 | do | 36 | 18.0 | 3.82 | 16.8 |
| March 19 | do | 27 | 11.9 | 3.69 | 12.0 |
| April 13 | do | 65 | 16.0 | 5.84 | 12.1 |
| April 27 | do | 11 | 4.1 | 5.82 | 5.6 |
| May 15 | do | 15 | 5.0 | 5.88 | 6.4 |
| June 26 | C. H. Lee | 11 | 2.1 | 5.80 | 2.6 |
| August 5 | R. S. Hawley | 3 | 0.8 | ..... | 0.8 |
| October 10 | W. F. Martin | 16 | 2.5 | ..... | 3.9 |
| November. 12 | W. V. Hardy | 14.5 | 5.7 | 5.80 | 7.6 |
| December 4 | do | 10 | 4.4 | 6.00 | 7.2 |
| December 29 | do | 12 | 6.0 | 6.10 | 14.9 |

*Daily gage height, in feet, of Temecula River near Temecula, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Dec. |
|---|---|---|---|---|---|---|---|---|
| 1 | 3.0 | 2.9 | 3.4 | 5.9 | 5.75 | 5.8 | 5.8 | ..... |
| 2 | 3.0 | 2.8 | 3.5 | 5.8 | 5.7 | 5.8 | 5.8 | ..... |
| 3 | 3.0 | 2.8 | 3.5 | 5.8 | 5.7 | 5.8 | 5.8 | 6.0 |
| 4 | 3.0 | 2.8 | 3.45 | 5.8 | 5.7 | 5.8 | 5.8 | 6.0 |
| 5 | 3.0 | 2.8 | 3.45 | 6.7 | 5.75 | 5.8 | 5.8 | 6.0 |
| 6 | 3.0 | 2.8 | 3.5 | 6.3 | 5.75 | 5.8 | 5.8 | 6.0 |
| 7 | 3.0 | 2.8 | 3.5 | 5.8 | 5.75 | 5.8 | 5.8 | 5.9 |
| 8 | 3.0 | 2.9 | 3.55 | 5.8 | 5.75 | 5.8 | 5.8 | 5.9 |
| 9 | 2.9 | 2.95 | 3.5 | 5.8 | 5.75 | 5.8 | 5.8 | 5.9 |
| 10 | 2.9 | 2.95 | 3.6 | 5.8 | 5.75 | 5.8 | 5.8 | 5.9 |
| 11 | 2.9 | 3.0 | 3.9 | 5.8 | 5.75 | 5.75 | 5.8 | 5.9 |
| 12 | 2.9 | 3.0 | 4.9 | 5.8 | 5.7 | 5.7 | 5.8 | 6.0 |
| 13 | 2.9 | 3.0 | 5.0 | 5.8 | 5.7 | 5.75 | 5.8 | 6.0 |
| 14 | 2.9 | 3.0 | 4.9 | 5.8 | 5.7 | 5.8 | 5.8 | 5.9 |
| 15 | 2.9 | 3.0 | 4.9 | 5.8 | 5.7 | 5.75 | 5.8 | 5.9 |
| 16 | 2.9 | 3.2 | 3.7 | 5.8 | 5.8 | 5.75 | 5.8 | 5.95 |
| 17 | 2.9 | 3.2 | 3.7 | 5.8 | 5.85 | 5.75 | 5.8 | 6.0 |
| 18 | 2.9 | 3.25 | 3.65 | 5.8 | 5.85 | 5.75 | ..... | 6.0 |
| 19 | 3.1 | 3.25 | 3.65 | 5.75 | 5.85 | 5.75 | ..... | 5.9 |
| 20 | 3.0 | 3.25 | 3.5 | 5.75 | 5.85 | 5.75 | ..... | 5.9 |
| 21 | 3.0 | 3.25 | 3.3 | 5.75 | 5.85 | 5.75 | ..... | 5.9 |
| 22 | 3.0 | 3.25 | 3.4 | 5.75 | 5.9 | 5.75 | ..... | 5.9 |
| 23 | 3.0 | 3.25 | 9.6 | 5.75 | 5.9 | 5.75 | ..... | 5.95 |
| 24 | 3.0 | 3.25 | 9.65 | 5.75 | 5.85 | 5.75 | ..... | 5.9 |
| 25 | 3.0 | 3.25 | 8.0 | 5.75 | 5.85 | 5.75 | ..... | ..... |
| 26 | 3.0 | 3.3 | 7.6 | 5.75 | 5.9 | 5.8 | ..... | 6.2 |
| 27 | 2.9 | 3.4 | 6.0 | 5.75 | 5.85 | 5.8 | ..... | 6.0 |
| 28 | 2.9 | 3.4 | 5.5 | 5.75 | 5.8 | 5.8 | ..... | 6.2 |
| 29 | 2.9 | ..... | 5.5 | 5.75 | 5.8 | 5.8 | ..... | 6.05 |
| 30 | 2.9 | ..... | 5.9 | 5.75 | 5.8 | 5.8 | ..... | 6.1 |
| 31 | 2.9 | ..... | 5.9 | ..... | 5.8 | ..... | ..... | 6.25 |

NOTE.—No gage height record was kept from July 18 to December 2. Discharges have not been computed on account of the small number of measurements at times of excessive changes in channel.

## SANTA ANA RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Santa Ana River has its source in the southern slope of the San Bernardino Mountains. It traverses the San Bernardino Valley in a southwesterly direction, breaks in a narrow canyon through the Santa Ana Mountains, and finally discharges through the Santa Ana Valley into the Pacific Ocean below the town of Santa Ana. Numerous tributaries rise in the southern slope of the San Bernardino Mountains, the surface flow of most of which reaches Santa Ana River, where it traverses San Bernardino Valley only in times of flood discharge. The topography on the higher elevations is rough and rugged, reaching elevations of from 10,000 to 12,000 feet, the formation being of granite with good soil covering and considerable growth of timber. On the lower elevations the topography is less rough and the soil covering is principally of brush. A gaging station is located on this stream at Warm Springs, about 8 miles above Redlands. Below this the river leaves the mountainous country and discharges over a sandy and gravelly bed through the San Bernardino Valley. During the summer months the entire flow of the stream is diverted above this gaging station and used for power development at the

mouth of the canyon, below which point it is again taken out and used for irrigation on the higher elevations of the San Bernardino Valley along the base of the mountains, where the country is under a high state of cultivation, principally for the raising of citrus fruits. The water rises to the surface in San Bernardino Valley near the city of San Bernardino and is diverted and used extensively for irrigation in the neighborhood of Riverside. In addition to this surface flow, a large number of wells have been sunk in this territory, many of which are artesian, while others require pumping. This developed water is also used extensively for irrigation in the vicinity of San Bernardino and Riverside. The water is again forced to the surface by bed-rock obstructions at Riverside Narrows below the city of Riverside, and gradually increases in volume until it reaches Santa Ana Canyon, where it is diverted for irrigation on the lower valley lands in the vicinity of Santa Ana and Fullerton. During the summer months measurements are made of the flow at Rincon, Cal., at the head of Santa Ana Canyon. There are only occasional flood discharges of this river which flow continuously from the mountain to the sea. The mean precipitation throughout this basin is from 15 to 30 inches, which falls in the form of rain except on the higher elevations of the San Bernardino Mountains, where there is a considerable snowfall, usually remaining on the extreme high elevations until midsummer. A storage reservoir has been constructed on Bear Creek, a tributary of this stream, and is known as the Bear Valley reservoir. This stored water is held until the summer months and used for irrigation in the San Bernardino Valley.

### SANTA ANA RIVER NEAR MENTONE, CAL.

This station was established in June, 1896. It is located 5 miles northeast of Mentone, Cal., three-fourths of a mile below the head works of the Mentone Power Company's canal and opposite the warm springs in the canyon.

The Edison Electric Company diverts the greater portion of the water from Santa Ana River above the gaging station, but also returns all of it above the station. They, however, allow only limited portions of the water to pass out of their conduits during certain hours of the day, holding back the water for the purpose of obtaining additional power when the greatest demand exists.

The Mentone Power Company's canal, formerly called the Santa Ana canal, diverts water above the station, all of which is returned below the point of measurement. During the low-water season the entire flow of the river is diverted by the canals. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 94, where are given also references to publications that contain data for previous years.

*Discharge measurements of Santa Ana River near Mentone, Cal., in 1906.*

| Date. | Hydrographer. | Gage height of river. | Discharge. | | |
|---|---|---|---|---|---|
| | | | River. | Mentone Power Company's canal. | Total for river. |
| | | *Feet.* | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* |
| January 20 | C. H. Lee | 2.17 | 87 | 37 | 124 |
| February 11 | do | 1.51 | 11 | 42 | 53 |
| February 11 | do | 1.57 | 15.8 | 42 | 58 |
| February 11 | do | 1.54 | 12.8 | 42 | 55 |
| February 12 | do | 1.45 | 6.7 | 52 | 59 |
| March 14 | do | 3.50 | 351 | 27 | 378 |
| March 16 | do | 5.40 | 1,410 | 49 | 1,460 |
| March 16 | do | 5.80 | 1,870 | 49 | 1,920 |
| March 17 | do | 4.15 | 677 | 0 | 677 |
| March 17 | do | 3.85 | 597 | 0 | 597 |
| March 18 | do | 3.70 | 405 | 11 | 416 |
| March 23 | M. P. Beeson | 3.05 | 156 | 55 | 211 |
| March 25 | do | 4.90 | 913 | 35 | 948 |
| March 26 | do | 6.35 | 2,250 | 34 | 2,280 |
| March 26 | do | 5.90 | 1,780 | 34 | 1,810 |
| March 27 | do | 5.25 | 1,200 | 25 | 1,220 |
| April 10 | C. H. Lee | 3.00 | 130 | 68 | 198 |
| April 21 | M. P. Beeson | 3.50 | 214 | 72 | 286 |
| May 12 | do | 3.60 | 148 | 71 | 219 |
| May 12 | do | 3.60 | 160 | 71 | 231 |
| June 2 | do | 3.50 | 149 | 66 | 215 |
| June 28 | do | 3.00 | 70 | 71 | 141 |
| August 4 | R. S. Hawley | 2.55 | 13.1 | 72 | 85 |
| October 11 | W. F. Martin | 2.31 | 2.9 | 61 | 64 |
| December 28 | do | 3.85 | 276 | 74 | 350 |

*Daily gage height, in feet, of Santa Ana River near Mentone, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.3 | 1.3 | 1.9 | 3.9 | 3.1 | 4.0 | 3.0 | 2.6 | 2.3 | 2.5 | 2.3 | 2.3 |
| 2 | 1.3 | 1.3 | 1.9 | 3.4 | 3.0 | 3.5 | 3.0 | 2.6 | 2.3 | 2.5 | 2.3 | 2.3 |
| 3 | 1.3 | 1.3 | 1.7 | 3.3 | 2.9 | 3.5 | 2.9 | 2.5 | 2.3 | 2.5 | 2.3 | 2.4 |
| 4 | 1.3 | 1.3 | 1.6 | 3.4 | 2.9 | 3.3 | 2.9 | 2.5 | 2.3 | 2.5 | 2.3 | 2.7 |
| 5 | 1.3 | 1.3 | 1.5 | 3.4 | 3.6 | 3.3 | 3.0 | 2.4 | 2.3 | 2.5 | 2.3 | 2.7 |
| 6 | 1.3 | 1.3 | 1.5 | 3.3 | 3.7 | 3.3 | 3.0 | 2.4 | 2.3 | 2.5 | 2.3 | 2.3 |
| 7 | 1.3 | 1.3 | 1.4 | 3.2 | 3.4 | 3.2 | 3.0 | 2.4 | 2.2 | 2.5 | 2.3 | 2.3 |
| 8 | 1.3 | 1.3 | 1.4 | 3.1 | 3.8 | 3.2 | 3.0 | 2.4 | 2.2 | 2.5 | 2.3 | 2.3 |
| 9 | 1.3 | 1.3 | 1.4 | 3.0 | 3.8 | 3.2 | 2.9 | 2.4 | 2.2 | 2.5 | 2.3 | 2.3 |
| 10 | 1.3 | 1.3 | 1.4 | 3.0 | 3.8 | 3.2 | 2.9 | 2.4 | 2.2 | 2.5 | 2.3 | 2.3 |
| 11 | 1.3 | 1.3 | 1.4 | 3.0 | 3.8 | 3.4 | 2.9 | 2.4 | 2.2 | 2.5 | 2.3 | 2.3 |
| 12 | 1.3 | 1.3 | 6.5 | 2.9 | 3.6 | 3.2 | 2.9 | 2.4 | 2.2 | 2.5 | 2.3 | 5.2 |
| 13 | 1.3 | 1.3 | 4.5 | 2.9 | 3.6 | 3.2 | 2.9 | 2.6 | 2.2 | 2.5 | 2.3 | 3.2 |
| 14 | 1.3 | 1.3 | 3.4 | 3.0 | 3.4 | 3.2 | 2.9 | 2.6 | 2.2 | 2.5 | 2.3 | 2.9 |
| 15 | 1.3 | 1.3 | 3.0 | 2.9 | 3.3 | 6.2 | 2.9 | 2.5 | 2.2 | 2.5 | 2.3 | 2.3 |
| 16 | 1.3 | 1.3 | 5.0 | 2.9 | 3.3 | 3.2 | 3.0 | 2.6 | 2.3 | 2.5 | 2.3 | 2.4 |
| 17 | 1.3 | 1.3 | 4.15 | 2.9 | 3.2 | 3.1 | 2.9 | 2.9 | 2.3 | 2.5 | 2.3 | 2.4 |
| 18 | 1.3 | 1.3 | 3.7 | 2.9 | 3.2 | 3.1 | 2.9 | 3.0 | 2.3 | 2.5 | 2.3 | 2.2 |
| 19 | 2.4 | 1.3 | 3.45 | 2.9 | 3.2 | 3.1 | 2.8 | 2.7 | 2.3 | 2.5 | 2.3 | 2.2 |
| 20 | 2.2 | 1.3 | 3.25 | 3.0 | 3.2 | 3.1 | 2.8 | 2.6 | 2.3 | 2.5 | 2.3 | 2.0 |
| 21 | 1.7 | 1.3 | 3.15 | 3.5 | 3.2 | 3.1 | 2.7 | 2.5 | 2.3 | 2.3 | 2.3 | 2.0 |
| 22 | 1.5 | 1.9 | 3.1 | 3.8 | 3.4 | 3.1 | 2.8 | 2.4 | 2.5 | 2.3 | 2.3 | 2.0 |
| 23 | 1.5 | 2.0 | 3.05 | 3.9 | 3.5 | 3.1 | 2.8 | 2.3 | 2.5 | 2.3 | 2.3 | 2.0 |
| 24 | 1.4 | 2.0 | 4.6 | 3.9 | 3.5 | 3.4 | 2.9 | 2.1 | 2.5 | 2.3 | 2.3 | 2.0 |
| 25 | 1.4 | 2.0 | 4.95 | 3.7 | 3.2 | 3.1 | 2.8 | 2.0 | 2.5 | 2.3 | 2.3 | 2.0 |
| 26 | 1.3 | 2.0 | 5.8 | 3.7 | 3.2 | 3.0 | 2.8 | 2.3 | 2.5 | 2.3 | 2.3 | 2.0 |
| 27 | 1.3 | 2.0 | 5.2 | 3.1 | 3.3 | 3.1 | 2.8 | 2.3 | 2.5 | 2.3 | 2.3 | 3.2 |
| 28 | 1.3 | 2.0 | 4.9 | 3.3 | 4.9 | 3.1 | 2.7 | 2.3 | 2.5 | 2.3 | 2.3 | 3.5 |
| 29 | 1.3 | ..... | 4.6 | 3.8 | 4.4 | 3.0 | 2.7 | 2.3 | 2.5 | 2.3 | 2.3 | 3.5 |
| 30 | 1.3 | ..... | 4.3 | 3.8 | 4.3 | 3.0 | 2.7 | 2.3 | 2.5 | 2.3 | 2.3 | 2.1 |
| 31 | 1.3 | ..... | 4.2 | ..... | 4.0 | ..... | 2.6 | 2.3 | ..... | 2.3 | ..... | 2.8 |

*Daily discharge, in second-feet, of Mentone Power Company's canal near Mentone, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 34 | 32 | 51 | 0 | 70 | 71 | 71 | 72 | 63 | 64 | 67 | 62 |
| 2 | 33 | 32 | 48 | 56 | 71 | 66 | 66 | 72 | 58 | 64 | 60 | 61 |
| 3 | 34 | 32 | 48 | 55 | 71 | 70 | 71 | 72 | 58 | 64 | 60 | 70 |
| 4 | 34 | 32 | 43 | 57 | 71 | 71 | 71 | 72 | 63 | 63 | 62 | 71 |
| 5 | 34 | 32 | 56 | 56 | 71 | 70 | 71 | 72 | 63 | 63 | 64 | 71 |
| 6 | 34 | 35 | 52 | 52 | 71 | 70 | 71 | 72 | 63 | 63 | 66 | 72 |
| 7 | 34 | 35 | 51 | 65 | 71 | 70 | 71 | 71 | 66 | 61 | 66 | 67 |
| 8 | 34 | 35 | 50 | 70 | 70 | 70 | 71 | 68 | 64 | 61 | 56 | 60 |
| 9 | 34 | 44 | 50 | 70 | 72 | 70 | 71 | 70 | 63 | 61 | 60 | 60 |
| 10 | 34 | 41 | 50 | 68 | 71 | 70 | 71 | 71 | 62 | 61 | 60 | 68 |
| 11 | 33 | 42 | 46 | 73 | 66 | 70 | 71 | 71 | 62 | 61 | 60 | 61 |
| 12 | 34 | 52 | 43 | 74 | 71 | 70 | 71 | 71 | 62 | 61 | 60 | 59 |
| 13 | 35 | 59 | 40 | 74 | 66 | 71 | 71 | 71 | 59 | 61 | 58 | 74 |
| 14 | 45 | 55 | 27 | 66 | 63 | 71 | 71 | 72 | 60 | 61 | 54 | 72 |
| 15 | 44 | 63 | 43 | 66 | 66 | 71 | 71 | 72 | 64 | 61 | 57 | 72 |
| 16 | 44 | 62 | 49 | 66 | 66 | 71 | 71 | 72 | 63 | 61 | 54 | 65 |
| 17 | 37 | 64 | 0 | 68 | 66 | 70 | 71 | 45 | 58 | 61 | 54 | 68 |
| 18 | 37 | 51 | 11 | 68 | 68 | 70 | 71 | 42 | 58 | 64 | 56 | 65 |
| 19 | 59 | 49 | 35 | 71 | 70 | 71 | 71 | 72 | 56 | 63 | 56 | 65 |
| 20 | 37 | 48 | 44 | 72 | 70 | 71 | 71 | 72 | 56 | 63 | 54 | 59 |
| 21 | 48 | 48 | 43 | 72 | 66 | 70 | 71 | 72 | 57 | 67 | 57 | 59 |
| 22 | 50 | 60 | 58 | 71 | 71 | 72 | 71 | 72 | 54 | 67 | 53 | 59 |
| 23 | 37 | 58 | 55 | 71 | 71 | 71 | 71 | 72 | 52 | 67 | 53 | 56 |
| 24 | 37 | 56 | 71 | 71 | 71 | 71 | 71 | 72 | 52 | 67 | 53 | 61 |
| 25 | 41 | 55 | 35 | 70 | 66 | 71 | 72 | 72 | 52 | 67 | 52 | 59 |
| 26 | 38 | 53 | 34 | 71 | 66 | 66 | 72 | 70 | 52 | 67 | 52 | 76 |
| 27 | 35 | 51 | 25 | 71 | 64 | 64 | 72 | 70 | 59 | 66 | 59 | 74 |
| 28 | 35 | 49 | 55 | 71 | 0 | 71 | 72 | 66 | 62 | 64 | 56 | 74 |
| 29 | 33 | ..... | 34 | 71 | 66 | 71 | 72 | 66 | 63 | 68 | 57 | 74 |
| 30 | 33 | ..... | 21 | 71 | 66 | 71 | 72 | 65 | 64 | 67 | 62 | 73 |
| 31 | 33 | ..... | 27 | ..... | 64 | ..... | 72 | 66 | ..... | 67 | ..... | 74 |

*Monthly discharge of Santa Ana River near Mentone, Cal., for 1906.*

[Drainage area, 182 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 181 | 34 | 46.8 | 2,880 | 0.257 | 0.30 |
| February | 121 | 33 | 63.1 | 3,500 | .347 | .36 |
| March | 2,440 | 51 | 530 | 32,600 | 2.91 | 3.36 |
| April | 495 | 186 | 274 | 16,300 | 1.50 | 1.67 |
| May | 536 | 163 | 245 | 15,100 | 1.35 | 1.56 |
| June | 329 | 135 | 172 | 10,200 | .945 | 1.05 |
| July | 140 | 90 | 119 | 7,320 | .654 | .75 |
| August | 111 | 67 | 80.5 | 4,950 | .442 | .51 |
| September | 74 | 58 | 64.1 | 3,810 | .352 | .39 |
| October | 74 | 66 | 71.4 | 4,390 | .392 | .45 |
| November | 69 | 54 | 60.3 | 3,590 | .331 | .37 |
| December | 859 | 56 | 111 | 6,820 | .610 | .70 |
| The year | 2,440 | 33 | 153 | 111,000 | .841 | 11.47 |

NOTE.—The discharge includes that of the Mentone Power Company's canal. Discharges for the river were obtained from rating tables covering short periods of time on account of the constant change in channel. Values are fair.

## SEEPAGE MEASUREMENTS.

In the vicinity of Colton and San Bernardino large quantities of water are developed in addition to the natural surface flow. This water is used for the irrigation of land in the vicinity of San Ber-

nardino, Colton, and Riverside, and also for domestic supply for these towns. Much of this water returns to Santa Ana River below Riverside, above a point known as Slover Mountain, and is again diverted and used for irrigation on the lower lands below Riverside and above what is known as Riverside Narrows. Below this point there are still further diversions which irrigate the lower lands along the river bottom, much of this water again returning to the river above Rincon. Measurements were made during the summers of 1905 and 1906 to determine the amount of water, including the natural flow and developed water, above Colton, Cal. Also measurements were made of natural flow and developed water below Slover Mountain and above Riverside Narrows, this all being return water from irrigated lands on the higher elevations. Measurements were also made of diversion ditches and Santa Ana River below Riverside Narrows and above what is known as the Auburndale Bridge. The following tabulations show the result of these measurements, which were made by K. Sanborn, of Riverside, Cal.

Measurements made during 1905 are contained in Water-Supply Paper No. 177, pages 99 to 102.

*Natural flow, in second-feet, of return water to Santa Ana River, compared with developed water in San Bernardino above Colton, Cal., 1906.*

[Measurements by Kingsbury Sanborn, engineer Riverside Water Company.]

| Date. | Location. | Developed. | Natural. | Total. |
|---|---|---|---|---|
| June 23 | Barnhill pumping plant | 1.30 | | 1.30 |
| August 27 | do | 1.50 | | 1.50 |
| June 18 | Beam ditch | | 0.00 | .00 |
| August 23 | do | | .00 | .00 |
| June 20 | Bloomington pumping plant | 10.50 | | 10.50 |
| September 20 | do | 6.70 | | 6.70 |
| September 20 | Citizens Water Co. pumping plant | 1.50 | | 1.50 |
| June 29 | City of San Bernardino, Sixth street pumping plant | 2.00 | | 2.00 |
| October 23 | do | 4.80 | | 4.80 |
| June 20 | City of San Bernardino, Lytle Creek | | 1.90 | 1.90 |
| September 20 | do | | 2.00 | 2.00 |
| June 19 | City of Colton pumping plant (total) | 2.40 | | 2.40 |
| August 27 | do | 3.50 | | 3.50 |
| June 19 | City of Colton (water used for irrigating) | .70 | | .70 |
| August 27 | do | 1.60 | | 1.60 |
| June 20 | Camp Carlton ditch | 2.70 | | 2.70 |
| September 7 | do | 1.94 | | 1.94 |
| June 19 | Carr pumping plant | .40 | | .40 |
| August 24 | do | .70 | | .70 |
| June 25 | Daley ditch | | .00 | .00 |
| October 24 | do | | .00 | .00 |
| June 27 | Excelsior Land and Water Co | .60 | | .60 |
| August 24 | do | .75 | | .75 |
| June 19 | Grand Terrace pumping plant | .30 | | .30 |
| September 7 | do | .35 | | .35 |
| June 20 | Gage Canal, Palm avenue weir | 22.90 | 8.30 | 31.20 |
| September 7 | do | 38.00 | | 38.00 |
| June 19 | Gage Canal intake, Santa Ana River | | 8.30 | 8.30 |
| September 7 | do | | .00 | .00 |
| June 14 | Haws & Talmadge ditch | | .05 | .05 |
| August 23 | do | | .08 | .08 |
| June 19 | Hunter pumping plant | 1.90 | | 1.90 |
| August 27 | do | 1.50 | | 1.50 |
| June 23 | Johnson & Hubbard pumping plant | .52 | | .52 |
| August 27 | do | .48 | | .48 |
| June 23 | Lamb pumping plant | .00 | | .00 |
| August 27 | do | .00 | | .00 |
| June 23 | Lawson Well Co. pumping plant | .60 | | .60 |
| August 27 | do | .70 | | .70 |
| June 18 | Logsdon & Farrell ditch | | .00 | .00 |

*Natural flow, in second-feet, of return water to Santa Ana River, compared with developed water in San Bernardino above Colton, Cal., 1906*—Continued.

| Date. | Location. | Developed. | Natural. | Total. |
|---|---|---|---|---|
| October 24 | Logedon & Farrell ditch | | 0.00 | 0.00 |
| June 20 | Lytle Creek Water and Improvement Co. pumping plant. | 0.00 | | .00 |
| September 20 | do | .00 | | .00 |
| June 28 | Merryfield pumping plant | .80 | | .80 |
| August 24 | do | .79 | | .79 |
| June 18 | McKenzie ditch | | .00 | .00 |
| August 23 | do | | .00 | .00 |
| June 28 | Meeks & Daley ditch | | 16.90 | 16.90 |
| August 31 | do | | 17.10 | 17.10 |
| June 22 | McIntyre ditch | | .00 | .00 |
| September 20 | do | | .00 | .00 |
| June 23 | Orange Land and Water Co. pumping plant | .00 | | .00 |
| August 27 | do | .00 | | .00 |
| June 20 | Riverside Highland Water Co. pumping plant | 3.60 | | 3.60 |
| September 20 | do | 6.10 | | 6.10 |
| June 20 | Riverside Highland Water Co., Santa Ana River | 1.80 | 2.50 | 4.30 |
| September 7 | do | 6.90 | | 6.90 |
| June 20 | Rancheria pumping plant | 2.00 | | 2.00 |
| September 20 | do | 1.90 | | 1.90 |
| June 14 | Rabel ditch | | .00 | .00 |
| August 23 | do | | .00 | .00 |
| June 19 | Riverside Water Co., upper canal | 2.90 | 38.60 | 41.50 |
| August 31 | do | 23.65 | 26.35 | 50.00 |
| June 23 | Riverside Water Co. mill pumping plant | .00 | | .00 |
| August 31 | do | .00 | | .00 |
| June 20 | Riverside Water Co. flume | | 16.70 | 16.70 |
| August 31 | do | | .00 | .00 |
| June 25 | Riverside Water Co. flume pump No. 1 | .00 | | .00 |
| August 31 | do | .00 | | .00 |
| June 25 | Riverside Water Co. flume pump No. 2 | .00 | | .00 |
| August 31 | do | .00 | | .00 |
| June 28 | Rosedale Water Co. pumping plant | .50 | | .50 |
| August 24 | do | .00 | | .00 |
| June 19 | Rogers pumping plant | 1.60 | | 1.60 |
| September 7 | do | 2.40 | | 2.40 |
| June 25 | Shay or Stout Dam ditch | | .00 | .00 |
| August 23 | do | | .24 | .24 |
| June 23 | Swamp ditch | | .80 | .80 |
| August 29 | do | | .64 | .64 |
| June 27 | West Riverside 350-inch Water Co. pumping plant | 6.00 | | 6.00 |
| August 31 | do | 6.50 | | 6.50 |
| June 22 | Whitlock ditch | | .00 | .00 |
| October 24 | do | | .00 | .00 |
| October 24 | Whiting ditch | | .00 | .00 |
| June 20 | Ward and Warren ditch | | 5.10 | 5.10 |
| September 7 | do | | .06 | .06 |

*Return waters, in second-feet, in San Bernardino Valley below Slover Mountain and above Riverside Narrows, 1906.*

[Measurements by Kingsbury Sanborn, engineer Riverside Water Company.]

| Date. | Location. | Developed. | Natural. | Total. |
|---|---|---|---|---|
| June 27 | Alvitrez ditch at headgate, east end of West Riverside Bridge | | 5.20 | 5.20 |
| August 28 | do | | 5.00 | 5.00 |
| June 29 | Cuttle's pumping plant | 2.50 | | 2.50 |
| September 7 | do | 2.50 | | 2.50 |
| June 29 | California Orange Co | 1.30 | | 1.30 |
| September 7 | do | 1.40 | | 1.40 |
| June 29 | Evans Island or Jansen ditch, under west end of West Riverside Bridge. | | .00 | .00 |
| September 3 | do | | .00 | .00 |
| June 26 | Evans ditch near county line | | 1.90 | 1.90 |
| September 3 | do | | .00 | .00 |
| June 23 | Evans Well ditch, Santa Ana street | | .00 | .00 |
| September 3 | do | | .00 | .00 |
| June 29 | Evans pipe line to China garden at headworks | | .00 | .00 |
| September 13 | do | | 2.70 | 2.70 |
| June 27 | Evans pumping plant 1,000 feet south of west end of West Riverside Bridge. | 3.60 | | 3.60 |
| August 28 | do | 5.53 | | 5.53 |
| June 29 | Evans Jurupa pumping plant | .00 | | .00 |
| June 30 | Ferris Gallagher ditch, near headworks | | 2.90 | 2.90 |
| September 13 | do | | 3.25 | 3.25 |
| June 30 | Gallagher ditch, near headworks | | .76 | .76 |
| September 13 | do | | .00 | .00 |

*Return waters, in second-feet, in San Bernardino Valley below Slover Mountain and above Riverside Narrows, 1906*—Continued.

| Date. | Location. | Developed. | Natural. | Total. |
|---|---|---|---|---|
| June 26 | Jurupa pumping plant to supply Rubidoux ditch | 2.30 | | 2.30 |
| September 3 | do | 5.20 | | 5.20 |
| June 27 | Lower canal, Riverside Water Co | | 3.10 | 3.10 |
| September 3 | do | | .00 | .00 |
| June 29 | Pond's pumping plant | 1.30 | | 1.30 |
| September 7 | do | 2.50 | | 2.50 |
| June 26 | Rubidoux ditch at measuring box | | 4.40 | 4.40 |
| September 3 | do | | 2.00 | 2.00 |
| June 21 | Riverside Power Co. canal at Pedley crossing | | 27.70 | 27.70 |
| September 29 | do | | 35.00 | 35.00 |
| June 29 | Rivino Land Co. pumping plant No. 1 | .80 | | .80 |
| September 7 | do | .70 | | .70 |
| September 13 | Rivino Land Co. pumping plant No. 2 | .83 | | .83 |
| June 25 | Smith or Evans ditch 1 mile below Riverside County line | | 1.70 | 1.70 |
| September 3 | do | | .00 | .00 |
| June 27 | Soquel ditch at intake | | 6.60 | 6.60 |
| August 28 | do | | 5.30 | 5.30 |
| June 23 | Spring Brook pumping plant at weir at end of main | .00 | | .00 |
| September 3 | do | .00 | | .00 |
| June 26 | Spanishtown pumping plant at weir at end of main | 4.60 | | 4.60 |
| September 3 | do | .00 | | .00 |
| June 30 | Zimmerman pipe line | | 2.20 | 2.20 |
| September 13 | do | | .00 | .00 |

*Discharge measurements, in second-feet, of canals between Riverside Narrows and the Auburndale Bridge having their source in Santa Ana River, 1906.*

| Date. | Location. | Discharge. |
|---|---|---|
| June 21 | Castile ditch near intake | 0.00 |
| September 29 | do | .00 |
| June 21 | Durkee ditch at Auburndale road crossing | 3.20 |
| September 29 | do | 3.50 |
| June 21 | Fuller ditch | 12.70 |
| September 29 | do | 6.70 |
| June 21 | Gilliland ditch at Auburndale road crossing | .17 |
| September 29 | do | .50 |
| June 21 | Newton ditch near intake | .00 |
| September 29 | do | .00 |
| June 21 | Newberry ditch at Auburndale road crossing | .00 |
| September 29 | do | 1.60 |
| June 21 | Roberts or LeGay ditch near intake, Santa Ana River | 2.60 |
| September 29 | do | 1.50 |
| June 21 | Wilbur ditch at Rogers pipe trestle crossing, Santa Ana River | .00 |
| September 29 | do | .00 |
| June 21 | Santa Ana River at Auburndale Bridge | 56.00 |
| September 29 | do | 52.00 |
| June 21 | Santa Ana River at Auburndale Bridge, including ditches | 59.37 |
| September 29 | do | 57.60 |

## MISCELLANEOUS MEASUREMENTS IN SANTA ANA RIVER DRAINAGE BASIN.

The following is a list of miscellaneous discharge measurements made in the Santa Ana River drainage basin during 1906.

*Cable Canyon Creek near Glen Helen, Cal.*—This stream is a tributary of the Santa Ana River. A measurement was made July 16, 1906, at the diversion weir in the canyon:

Diversion over weir, 1.1 second-feet; waste below weir, 2.1 second-feet; total flow of creek, 2.2 second-feet.

*Cajon Creek near Keenbrook, Cal.*—This stream is a tributary of Lytle Creek. A measurement was made July 16, 1906, in the canyon at Keenbrook:

Width, 3 feet; area, 1.3 square feet; discharge, 3.3 second-feet.

*Chino Creek near Rincon, Cal.*—This stream is a tributary of Santa Ana River. The following measurements were made during 1906, at the wagon bridge at Rincon road crossing, one-fourth mile above junction with Santa Ana River:

June 25: Width, 3 feet; area, 1.5 square feet; discharge, 3.9 second-feet.
August 31: Width, 3.5 feet: area, 1.3 square feet; discharge, 2.6 second-feet.
November 7: Width, 5.5 feet; area, 6.2 square feet; discharge, 10.3 second-feet.

*Devil Canyon Creek near Irvington, Cal.*—This stream is a tributary of Santa Ana River. A measurement was made July 14, 1906, at the mouth of the canyon:

Width, 4 feet; area, 2.4 square feet; discharge, 5.2 second-feet.

*East Twin Creek near Arrowhead Springs, Cal.*—This stream is a tributary of the Santa Ana River. A measurement was made July 14, 1906, in the canyon above the canal diversion:

Width, 2 feet; area, 1.8 square feet; discharge, 2.7 second-feet.

*Lytle Creek near Rialto, Cal.*—This stream is one of the principal tributaries of Santa Ana River. A measurement was made July 16, 1906, at the head of the Fontella Development Company's canal at the mouth of the canyon:

Diversion over weir, 25.4 second-feet; waste below weir, 56 second-feet; total flow of creek, 81.4 second-feet.

*Santa Ana River near Rincon, Cal.*—The following measurements were made during 1906, at the Rincon wagon bridge, at the lower end of the San Bernardino Valley and at the head of the lower Santa Ana Canyon. These measurements, with the addition of those of Chino Creek, show the total discharge of Santa Ana River below all diversions in the San Bernardino Valley, and show the amount of water used for irrigation in the vicinity of Orange, Santa Ana, Anaheim, and Fullerton, Cal., diversions being made below this point of measurement:

June 25: Width, 47 feet; area, 40 square feet; discharge, 82 second-feet.
August 3: Width, 47 feet; area, 33 square feet; discharge, 56 second-feet.
November 7: Width, 43 feet; area, 45 square feet; discharge, 94 second-feet.

*Waterman Canyon or West Twin Creek near Arrowhead Springs, Cal.*—This stream is a tributary of Santa Ana River. A measurement was made July 14, 1906, at the crossing on the road to Waterman Ranch near the mouth of the canyon:

Width, 4.7 feet; area, 3.6 square feet; discharge, 4 second-feet.

## SAN GABRIEL RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

San Gabriel River rises in the Sierra Madre Mountains and, flowing in a southwesterly direction through the San Gabriel and Los Angeles valleys, discharges its waters into the Pacific Ocean near Long Beach, Cal. In the upper reaches of this basin there are

numerous tributaries, which have their source in the higher elevations of the Sierra Madre Range. The topography in the upper reaches of this basin is rough and rugged, with deep and narrow canyons, while on the lower elevations the country is rolling, with large areas of valley land. The formation on the higher mountain elevation is of granite, with a light soil covering, with sparse timber growth. As one approaches the middle elevations the covering is brush, with scattering timber, while in the foothill country there is nothing but a growth of grass. The gaging station on this stream is located at a point where the stream leaves the higher mountains in the vicinity of Azusa. Below this point the river enters the San Gabriel Valley, where the stream has a comparatively light grade, the bed being composed of bowlders, gravel, and sand, in which the water quickly disappears, except in times of flood discharge. The waters of this stream again appear on the surface at the lower end of the San Gabriel Valley, at the point of discharge from the foothills, where an obstruction to the underground passage forces the water to the surface, on which it flows for a short distance and again disappears in the sands of the flat country below the foothills. The entire flow of this stream during the summer months is diverted at a point about 5 miles above the gaging station and is used for power purposes at the mouth of the canyon. From this point it is carried in ditches and used for irrigation in the San Gabriel Valley. The water is again diverted where it appears on the surface at the lower end of this valley and is used for irrigation on the lower levels below this point. The mean precipitation in this basin varies from 15 to 30 inches and is principally in the form of rain. On small areas in the higher mountain elevations the precipitation is in the form of snow, which melts in the early spring months.

### SAN GABRIEL RIVER AND CANALS NEAR AZUSA, CAL.

Owing to the numerous diversions, it has been difficult to obtain accurate discharge measurements at Azusa, but during 1898 the San Gabriel Electric Company completed its system, and measurements are now obtained with greater ease and hence with greater accuracy. The head works of this company are located about 6 miles above the mouth of the canyon. The water is carried around the left side by a series of tunnels and conduits, and a head of 400 feet is obtained where the electric power is generated. Weirs are placed on the conduit of the electric company and the water is measured at this point. The capacity of the conduit is 80 second-feet.

The cable and gage are located about 1 mile from Azusa. During the season of low water for a period of from six to eight months the canals above the station divert the entire flow and there is no running water at the station. The total flow of the river is obtained by adding the daily discharge for the river to the figures for the cor-

responding dates for the canals. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 104, where are given also references to publications that contain data for previous years.

*Discharge measurements of San Gabriel River and canals near Azusa, Cal., in 1906.*

| Date. | Hydrographer. | Gage height. | Discharge. | | |
|---|---|---|---|---|---|
| | | | River. | Canal. | Total. |
| | | *Feet.* | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* |
| January 19 | M. P. Beeson | 3.88 | 375 | 0 | 375 |
| January 20 | do | 2.90 | 104 | 76 | 180 |
| January 20 | do | 2.95 | 110 | 76 | 186 |
| February 10 | do | 1.70 | 3.5 | 57 | 60 |
| February 15 | do | 2.70 | 60 | 15 | 75 |
| February 15 | do | 2.70 | 69 | 15 | 84 |
| February 17 | do | 2.60 | 49 | 40 | 89 |
| March 12 | do | 6.60 | 4,940 | 74 | 5,010 |
| March 13 | do | 5.90 | 3,360 | 74 | 3,430 |
| March 13 | do | 5.40 | 2,530 | 74 | 2,600 |
| March 14 | do | 4.40 | 1,210 | 74 | 1,280 |
| March 17 | do | 5.28 | 2,190 | 78 | 2,270 |
| March 17 | do | 5.15 | 2,140 | 78 | 2,220 |
| March 18 | do | 4.70 | 1,440 | 78 | 1,520 |
| March 21 | do | 4.00 | 666 | 72 | 738 |
| March 21 | do | 4.00 | 688 | 72 | 760 |
| March 30 | do | 5.10 | 1,380 | 76 | 1,460 |
| April 4 | do | 4.50 | 757 | 76 | 833 |
| April 18 | do | 3.80 | 394 | 76 | 470 |
| April 18 | do | 3.80 | 436 | 76 | 512 |
| May 11 | do | 3.30 | 209 | 76 | 285 |
| May 11 | do | 3.30 | 212 | 76 | 288 |
| June 1 | do | 3.55 | 292 | 54 | 346 |
| June 1 | do | 3.55 | 273 | 54 | 327 |
| June 29 | C. H. Lee | 2.90 | 157 | 76 | 233 |
| July 30 | W. B. Clapp | 2.20 | 25 | 76 | 101 |
| December 28 | W. B. Clapp and R. S. Hawley | 5.20 | 1,500 | 76 | 1,580 |

*Daily gage height, in feet, of San Gabriel River near Azusa, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Dec. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | 4.8 | 3.4 | 3.6 | 2.8 | 2.1 | |
| 2 | | | | 4.7 | 3.4 | 3.6 | 2.8 | 2.0 | |
| 3 | | | | 4.7 | 3.4 | 3.5 | 2.8 | 1.9 | |
| 4 | | | 2.6 | 4.5 | 3.4 | 3.5 | 2.75 | 1.9 | |
| 5 | | | 2.7 | 4.7 | 3.45 | 3.4 | 2.75 | 1.85 | |
| 6 | | | | 4.4 | 3.45 | 3.4 | 2.7 | 1.8 | |
| 7 | | | | 4.2 | 3.4 | 3.4 | 2.75 | 1.7 | |
| 8 | | | | 4.2 | 3.4 | 3.3 | 2.7 | 1.7 | |
| 9 | | | | 4.2 | 3.4 | 3.3 | 2.7 | 1.65 | |
| 10 | | | | 4.2 | 3.4 | 3.2 | 2.7 | 1.6 | |
| 11 | | | | 4.2 | 3.4 | 3.2 | 2.6 | 1.6 | |
| 12 | | | 7.9 | 4.1 | 3.3 | 3.2 | 2.6 | 1.55 | 4.0 |
| 13 | | 2.7 | 7.2 | 4.0 | 3.3 | 3.1 | 2.6 | 1.5 | 3.8 |
| 14 | | 2.7 | 4.35 | 4.0 | 3.3 | 3.1 | 2.6 | 1.4 | 3.5 |
| 15 | | 2.7 | 4.5 | 4.0 | 3.3 | 3.1 | 2.6 | 1.3 | 3.0 |
| 16 | | 2.7 | 4.8 | 3.9 | 3.3 | 3.05 | 2.6 | | 2.3 |
| 17 | | 2.6 | 5.2 | 3.8 | 3.3 | 3.0 | 2.55 | | 2.1 |
| 18 | | 2.1 | 4.8 | 3.8 | 3.2 | 3.0 | 2.55 | | 2.1 |
| 19 | 3.9 | 2.0 | 4.8 | 3.8 | 3.2 | 3.0 | 2.55 | | 2.1 |
| 20 | 2.9 | 2.0 | 4.6 | 3.8 | 3.2 | 3.0 | 2.55 | | 1.8 |
| 21 | 2.7 | 1.9 | 4.3 | 3.7 | 3.2 | 2.95 | 2.55 | | |
| 22 | 2.3 | 2.3 | 4.1 | 3.6 | 3.2 | 2.95 | 2.5 | | |
| 23 | 2.0 | 2.0 | 4.1 | 3.6 | 3.2 | 2.9 | 2.5 | | |
| 24 | 1.75 | 1.9 | 5.15 | 3.6 | 3.1 | 2.9 | 2.4 | | |
| 25 | 1.6 | 1.9 | 7.55 | 3.6 | 3.1 | 3.0 | 2.4 | | |
| 26 | | 1.8 | 8.45 | 3.5 | 3.4 | 2.9 | 2.35 | | |
| 27 | | | 7.45 | 3.5 | 3.3 | 2.95 | 2.35 | | 2.0 |
| 28 | | | 6.7 | 3.7 | 4.8 | 2.95 | 2.3 | | 5.2 |
| 29 | | | 6.65 | 3.5 | 4.1 | 2.9 | 2.25 | | 3.8 |
| 30 | | | 5.1 | 3.4 | 3.75 | 2.85 | 2.2 | | 3.5 |
| 31 | | | 5.1 | | 3.7 | | 2.15 | | 3.2 |

NOTE.—The river was dry January 1 to 18, January 26 to February 12, February 27 to March 3, March to 11, August 16 to December 11, and December 21 to 26.

*Daily discharge in second-feet of San Gabriel Canals near Azusa, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 37 | 50 | 75 | 78 | 76 | 54 | 76 | 76 | 54 | 42 | 38 | 45 |
| 2 | 37 | 50 | 68 | 52 | 76 | 52 | 76 | 76 | 55 | 42 | 38 | 46 |
| 3 | 37 | 49 | 65 | 58 | 76 | 54 | 76 | 76 | 53 | 42 | 38 | 58 |
| 4 | 37 | 50 | 20 | 76 | 76 | 65 | 76 | 76 | 52 | 42 | 38 | 64 |
| 5 | 37 | 63 | 20 | 74 | 76 | 76 | 76 | 76 | 52 | 41 | 38 | 51 |
| 6 | 37 | 63 | 74 | 76 | 76 | 76 | 76 | 76 | 50 | 40 | 39 | 51 |
| 7 | 37 | 56 | 70 | 78 | 76 | 76 | 76 | 76 | 50 | 40 | 39 | 47 |
| 8 | 37 | 47 | 70 | 78 | 76 | 76 | 76 | 76 | 49 | 40 | 39 | 47 |
| 9 | 37 | 47 | 71 | 77 | 76 | 76 | 76 | 76 | 49 | 40 | 38 | 50 |
| 10 | 36 | 57 | 64 | 76 | 76 | 76 | 76 | 76 | 49 | 40 | 38 | 76 |
| 11 | 36 | 72 | 56 | 65 | 76 | 76 | 76 | 76 | 49 | 40 | 38 | 60 |
| 12 | 37 | 69 | 74 | 74 | 76 | 76 | 76 | 76 | 49 | 40 | 38 | 75 |
| 13 | 37 | 15 | 74 | 78 | 76 | 76 | 76 | 76 | 50 | 40 | 38 | 76 |
| 14 | 49 | 15 | 74 | 76 | 76 | 76 | 76 | 76 | 50 | 39 | 38 | 76 |
| 15 | 52 | 15 | 77 | 76 | 76 | 76 | 76 | 76 | 52 | 38 | 38 | 76 |
| 16 | 41 | 15 | 78 | 76 | 76 | 76 | 76 | 76 | 51 | 38 | 38 | 76 |
| 17 | 41 | 40 | 78 | 72 | 76 | 76 | 76 | 76 | 50 | 39 | 38 | 76 |
| 18 | 42 | 74 | 78 | 76 | 76 | 76 | 76 | 72 | 46 | 39 | 37 | 76 |
| 19 | 0 | 74 | 77 | 76 | 76 | 76 | 76 | 68 | 45 | 40 | 37 | 76 |
| 20 | 76 | 74 | 75 | 76 | 76 | 76 | 76 | 68 | 45 | 41 | 38 | 72 |
| 21 | 76 | 75 | 72 | 76 | 76 | 76 | 76 | 68 | 44 | 40 | 41 | 65 |
| 22 | 76 | 74 | 71 | 76 | 76 | 76 | 76 | 68 | 44 | 40 | 45 | 62 |
| 23 | 76 | 74 | 65 | 76 | 76 | 76 | 76 | 68 | 43 | 40 | 47 | 59 |
| 24 | 76 | 74 | 78 | 76 | 76 | 76 | 76 | 66 | 43 | 40 | 45 | 58 |
| 25 | 66 | 70 | 76 | 76 | 76 | 76 | 76 | 64 | 43 | 40 | 45 | 58 |
| 26 | 66 | 70 | 78 | 76 | 76 | 76 | 76 | 60 | 43 | 40 | 46 | 76 |
| 27 | 61 | 73 | 78 | 76 | 76 | 76 | 76 | 60 | 43 | 39 | 46 | 76 |
| 28 | 57 | 76 | 78 | 76 | 76 | 76 | 76 | 59 | 43 | 38 | 45 | 76 |
| 29 | 58 | ..... | 76 | 76 | 53 | 76 | 76 | 59 | 42 | 38 | 45 | 76 |
| 30 | 54 | ..... | 76 | 76 | 48 | 76 | 76 | 58 | 42 | 38 | 45 | 76 |
| 31 | 52 | ..... | 78 | ..... | 60 | ..... | 76 | 57 | ..... | 38 | ..... | 76 |

*Monthly discharge of San Gabriel River near Azusa, Cal., for 1906.*

[Drainage area, 222 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 441 | 36 | 68.1 | 4,190 | 0.307 | 0.35 |
| February | 92 | 47 | 68.1 | 3,780 | .307 | .32 |
| March | 9,430 | 56 | 2,160 | 133,000 | 9.73 | 11.22 |
| April | 1,110 | 321 | 578 | 34,400 | 2.60 | 2.90 |
| May | 1,110 | 251 | 342 | 21,000 | 1.54 | 1.78 |
| June | 364 | 204 | 262 | 15.600 | 1.18 | 1.32 |
| July | 295 | 97 | 155 | 9,530 | .698 | .80 |
| August | 93 | 57 | 72.8 | 4,480 | .328 | .38 |
| September | 55 | 42 | 47.7 | 2,840 | .215 | .24 |
| October | 42 | 38 | 39.8 | 2,450 | .179 | .21 |
| November | 47 | 37 | 40.4 | 2,400 | .182 | .20 |
| December | 1,600 | 45 | 188 | 11,600 | .847 | .98 |
| The year | 9,430 | 36 | 335 | 245,000 | 1.51 | 20.70 |

NOTE.—These discharges include the water in the canals. The discharge of the river has been obtained from rating tables covering short periods of time, on account of the constant change in channel. Values are fair.

## LOS ANGELES RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Los Angeles River is formed by Tujunga, Pacoima, and other small creeks which have their source in the Sierra Madre Range of mountains to the northeast of the city of Los Angeles. These streams leave

the mountains at a point about 25 miles above the city and enter the comparatively flat country of the San Fernando Valley, where, except in times of excessive flood, the waters disappear in the sand and gravel washes, to reappear at the lower end of this valley, where a secondary range of hills, extending from east to west, forces them to the surface to form what is known as Los Angeles River. Below this point the river discharges through the flat country of the Los Angeles Valley, finally entering the Pacific Ocean near the town of Long Beach, Cal. During the summer months the entire flow of Los Angeles River is diverted at a point about 5 miles above Los Angeles for the supply of the city, only a small amount of water passing this point except during flood discharges. The topography is rough in the upper reaches of this drainage basin, the streams flowing in deep, narrow canyons. In this portion of the basin the formation is of granite, with good soil covering and light timber and heavy brush growth. There is a considerable area of foothill country within this basin, lying between the base of the Sierra Madre Range and the Los Angeles Valley, which has a light covering of brush and grass. The soil of the San Fernando Valley consists, principally, of river wash, coarse sand, and gravel, except along the base of the mountains and foothills, where the soil is of good depth and is under a high state of cultivation. The soil of the Los Angeles Valley, below the city of Los Angeles, consists of a light sandy loam and is under a high state of cultivation. The mean precipitation throughout the basin is from 15 to 30 inches and falls in the form of rain, except on small areas on the higher mountain elevations.

### MISCELLANEOUS MEASUREMENTS IN LOS ANGELES RIVER DRAINAGE BASIN.

The following is a list of miscellaneous discharge measurements made in Los Angeles River drainage basin during 1906:

*Arroyo Seco near Pasadena, Cal.*—This stream is a tributary of Los Angeles River. The following measurements were made on this stream during 1906:

April 18, at mouth of canyon, 5 miles above Pasadena, Cal.: Width, 16.5 feet; area, 11.6 square feet; discharge, 20 second-feet.

April 18, at Devils Gate, 3 miles above Pasadena, Cal.: Width, 11 feet; area, 5.9 square feet; discharge, 9.2 second-feet.

April 18, at submerged dam of Pasadena Land and Water Company at Pasadena, Cal.: Discharge, 0.0 second-feet.

*Los Angeles River at Seventh Street Bridge, Los Angeles, Cal.*—The following measurements were made on Los Angeles River:

March 13, a. m.: Width, 80 feet; area, 166 square feet; discharge, 850 second-feet.

March 13, p. m.: Width, 80 feet; area, 136 square feet; discharge, 555 second-feet.

March 16: Width, 58 feet; area, 43 square feet; discharge, 75 second-feet.

March 17, a. m.: Width, 80 feet; area, 194 square feet; discharge, 1,200 second-feet.

March 17, p. m.: Width, 73 feet; area, 103 square feet; discharge, 420 second-feet.

*Diversions from Los Angeles River.*—During the summer of 1906 measurements were made to determine the amount of water diverted by the city of Los Angeles for domestic supply, this being ascertained by measurements made in the 44-inch conduit and in the main-supply conduit. The supply is taken from the river near Burbank and includes both surface and underground diversions and constitutes the entire flow of the river at this point during the summer months. Some return seepage water again appears in the river channel near Huron street, Los Angeles, near which point the city has an underground gallery or tunnel for collecting an auxiliary supply which is pumped to the reservoir and used in the general distributing system. The following measurements were made of these diversions during 1906:

*Measurements of flow, in second-feet, of diversions from Los Angeles River by the city of Los Angeles in 1906.*

| Date. | 44-inch conduit discharge. | Main-supply conduit discharge. | Total. |
|---|---|---|---|
| February 24 | 26.59 | 6.58 | 33.17 |
| April 20 | 36.23 | 7.67 | 43.90 |
| June 23 | 31.76 | 15.86 | 47.62 |
| July 17 | 34.73 | 9.43 | 44.16 |
| July 20 | 33.95 | 10.23 | 44.18 |
| August 22 | 30.49 | 13.67 | 44.16 |
| August 31 | 32.86 | 11.30 | 44.16 |
| September 21 | 38.11 | 4.43 | 42.54 |
| September 23 | 29.48 | 13.20 | 42.68 |
| November 22 | 32.73 | 13.50 | 46.23 |
| December 18 | 33.61 | 15.66 | 49.27 |

NOTE.—On February 24, 23.9 second-feet was passing intake and is not included in above total. On April 20, 7.4 second-feet was passing intake and is not included in above total.

## MALIBU CREEK DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Malibu Creek rises in the Santa Monica Mountains and enters the Pacific Ocean about 15 miles above the town of Santa Monica. This stream is formed by Triunfo and Las Virgenes creeks, which drain the northern portion of the Santa Monica Range and the lower foothill country to the north. The formation throughout this basin is shale, sandstone, and conglomerate, with good soil covering. There is a sparse growth of timber on the higher elevations, but the greater portion of this area has a covering of brush and grass and is used extensively for pasturage, with limited areas of cultivated land for the raising of grain. A reservoir has been constructed on the upper reaches of the Triunfo Creek and the waters are used for irrigation within the basin during the summer months. This reservoir covers an area of about 300 acres when filled. The mean precipitation is about 25 inches and falls wholly in the form of rain.

### MALIBU CREEK NEAR CALABASAS, CAL.

This station was established November 29, 1901, by S. G. Bennett. It is located at Chapman's ranch, 40 miles from Los Angeles by wagon road and 8 miles southwest of Calabasas, about one-fourth mile below the mouth of Las Virgenes Creek. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 111, where are given also references to publications that contain data for previous years.

*Discharge measurements of Malibu Creek near Calabasas, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 11 | C. H. Lee | 6 | 1.2 | 0.85 | 1.0 |
| March 12 | do | 33 | 45 | 2.30 | 122 |
| March 25[a] | do | | 94 | 2.80 | 406 |
| April 18 | do | 20 | 11.1 | 1.30 | 19 |
| May 24 | do | 16 | 6.4 | 1.00 | 7.1 |

[a] Measured by floats.

*Daily gage height, in feet, of Malibu Creek near Calabasas, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.6 | 0.6 | 1.0 | 1.85 | 1.1 | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | a0.9 | 0.9 |
| 2 | .6 | .6 | 1.0 | 1.8 | 1.1 | 1.0 | 1.0 | .9 | .9 | .9 | a.9 | .9 |
| 3 | .6 | .6 | 1.0 | 1.7 | 1.1 | 1.0 | 1.0 | .9 | .9 | .9 | a.9 | .9 |
| 4 | .6 | .7 | 0.8 | 1.6 | 1.1 | 1.0 | 1.0 | .9 | .9 | .9 | a.9 | .9 |
| 5 | .6 | .7 | .8 | 1.5 | 1.1 | 1.0 | .95 | .9 | .9 | .9 | a.9 | .9 |
| 6 | .6 | .7 | .8 | 1.4 | 1.1 | 1.0 | .9 | .9 | .9 | .9 | a.9 | .9 |
| 7 | .6 | .7 | .7 | 1.35 | 1.1 | 1.0 | .9 | .9 | .9 | .9 | a.9 | .9 |
| 8 | .6 | .7 | .7 | 1.4 | 1.1 | 1.0 | .9 | .9 | .9 | .9 | a.9 | .9 |
| 9 | .6 | .7 | .8 | 1.4 | 1.1 | 1.0 | .9 | .9 | a.9 | .9 | a.9 | .9 |
| 10 | .6 | .7 | .8 | 1.4 | 1.05 | 1.0 | .9 | .9 | a.9 | .9 | a.9 | 1.0 |
| 11 | .6 | .6 | .9 | a1.4 | 1.05 | 1.0 | .9 | .9 | a.9 | .9 | .9 | 1.05 |
| 12 | .6 | .6 | 2.55 | 1.4 | 1.05 | 1.0 | .9 | .9 | a.9 | .9 | .9 | 1.4 |
| 13 | .6 | .6 | 2.2 | 1.25 | 1.05 | 1.0 | .9 | .9 | a.9 | .9 | .9 | 1.0 |
| 14 | .7 | 1.1 | 1.55 | 1.25 | 1.05 | 1.0 | .9 | .9 | a.9 | .9 | .9 | 1.0 |
| 15 | .7 | 1.25 | 1.2 | 1.2 | 1.05 | 1.0 | .9 | .9 | a.9 | .9 | .9 | 0.9 |
| 16 | .7 | .7 | 2.6 | 1.2 | 1.05 | 1.0 | .9 | .9 | a.85 | .9 | .9 | .85 |
| 17 | .7 | .7 | 2.1 | 1.2 | 1.0 | 1.0 | .9 | .9 | a.85 | .9 | .9 | .85 |
| 18 | .7 | .7 | a1.8 | 1.3 | 1.0 | 1.0 | .9 | .9 | a.85 | .9 | .9 | .8 |
| 19 | .7 | .7 | a1.6 | 1.3 | 1.0 | 1.0 | .9 | .9 | a.85 | .9 | .9 | .8 |
| 20 | .7 | .7 | 1.45 | 1 3 | 1.0 | 1.0 | .9 | .9 | a.85 | .9 | .9 | .8 |
| 21 | 1.0 | .7 | 1.68 | 1.3 | 1.0 | 1.0 | .9 | .9 | a.85 | .9 | .9 | .8 |
| 22 | 1.0 | .7 | 1.55 | 1.05 | 1.0 | 1.0 | .9 | .9 | .8 | .9 | .9 | .8 |
| 23 | 1.0 | .7 | 1.5 | 1.05 | 1.0 | 1.0 | .9 | .9 | a.8 | .9 | .9 | .8 |
| 24 | 1.0 | .7 | 3.4 | 1.05 | a1.0 | 1.0 | .9 | .9 | a.8 | .9 | .9 | .8 |
| 25 | 1.0 | 1.0 | 2.92 | 1.05 | a1.1 | 1.0 | .9 | .9 | a.8 | .9 | .9 | .8 |
| 26 | 1.0 | 1.0 | 5.55 | 1.05 | 1.1 | 1.0 | .9 | .9 | a.8 | a.9 | .9 | .85 |
| 27 | 1.0 | 1.0 | 3.35 | 1.1 | 1.2 | 1.0 | .9 | .9 | a.85 | a.9 | .9 | 1.85 |
| 28 | 0.6 | 1.0 | 2.9 | 1.1 | 1.2 | 1.0 | .9 | .9 | a.85 | a.9 | .9 | 2.6 |
| 29 | .6 | ..... | 2.1 | 1.1 | 1.1 | 1.0 | .9 | .9 | a.85 | a.9 | .9 | 1.45 |
| 30 | .6 | ..... | 1.98 | 1.1 | 1.0 | 1.0 | .9 | .9 | a.85 | a.9 | .9 | 1.2 |
| 31 | .6 | ..... | 1.9 | ..... | 1.0 | ..... | .9 | .9 | ..... | a.9 | ..... | 2.2 |

[a] Estimated.

*Monthly discharge of Malibu Creek near Calabasas, Cal., for 1906.*

[Drainage area, 97 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 3 | 0.8 | 1.3 | 80 | 0.013 | 0.01 |
| February | 12 | .8 | 1.8 | 100 | .019 | .02 |
| March | 2,600 | .9 | 223 | 13,700 | 2.30 | 2.65 |
| April | 62 | 9 | 22.1 | 1,320 | .228 | .25 |
| May | 15 | 7 | 9.1 | 560 | .094 | .11 |
| June | 7 | 7 | 7.1 | 422 | .073 | .08 |
| July | 7 | 4 | 4.8 | 295 | .049 | .06 |
| August | 4.4 | 4.4 | 4.4 | 271 | .045 | 05 |
| September | 4.4 | 2 | 3.6 | 214 | .037 | .04 |
| October | 4.4 | 4.4 | 4.4 | 271 | .045 | .05 |
| November | 4.4 | 4.4 | 4.4 | 262 | .045 | .05 |
| December | 275 | 2 | 19.8 | 1,220 | .204 | .24 |
| The year | 2,600 | .8 | 25.5 | 18,700 | .261 | 3.61 |

NOTE.—Discharges were obtained by the indirect method for shifting channels. Owing to the small number of measurements and the shifting conditions, these values are only roughly approximate.

## TRIUNFO CREEK, NEAR CALABASAS, CAL.

This station is located 8 miles southwest of Calabasas, Cal., about one-half mile above the mouth of Las Virgenes Creek. The conditions and the bench marks are described in Water-Supply Paper No. 177, page 113, where are given also references to publications that contain data for previous years.

*Discharge measurements on Triunfo Creek near Calabasas, Cal., by C. H. Lee, in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 11 | 5.5 | 1.16 | 1.25 | 0.8 | March 25 | 114 | 100 | 3.00 | 399 |
| March 11 | 6.0 | 1.5 | 1.38 | 1.8 | March 26[a] | | 318 | 4.50 | 2,320 |
| March 12 | 34 | 29 | 2.25 | 98 | April 18 | 22 | 10.5 | 2.00 | 19 |
| March 25 | 120 | 114 | 2.95 | 459 | May 24 | 11 | 5 | 2.05 | 6.1 |
| March 25 | 64 | 81 | 2.79 | 313 | | | | | |

[a] Measured by floats.

*Monthly discharge of Triunfo Creek near Calabasas, Cal., for 1906.*

[Drainage area, 72 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft per sq. mile. | Depth in inches. |
| January | 0.7 | 0 | 0.2 | 12 | 0.0028 | 0.003 |
| February | 10 | 0 | 1.1 | 61 | .015 | .02 |
| March | 2,000 | 6 | 155 | 9,530 | 2.15 | 2.48 |
| April | 55 | 8 | 19.3 | 1,150 | .268 | .30 |
| May | 12 | 5 | 6.9 | 424 | .096 | .11 |
| June | 6 | 6 | 6.0 | 357 | .083 | .09 |
| July | 6 | 3 | 3.6 | 221 | .050 | .06 |
| August | 3 | 0 | 1.7 | 105 | .024 | .03 |
| September | 0 | 0 | 0.0 | 0 | .00 | .00 |
| October | 0 | 0 | 0.0 | 0 | .00 | .00 |
| November | 4 | 0 | 1.5 | 89 | .021 | .02 |
| December | 100 | 2 | 10.8 | 664 | .150 | .17 |
| The year | 2,000 | 0 | 17.2 | 11,600 | 0.238 | 3.28 |

NOTE.—The above values are based on very meager data and are only approximate.

## VENTURA RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Ventura River rises in the Santa Ynez Mountains (a portion of the Coast Range), in Ventura County. It flows in a southerly direction, discharging its waters into the Pacific Ocean at Ventura, Cal. Above the Ojai Valley this stream is known as Matilija Creek. The drainage basin is not large, but heavy floods of short duration are of frequent occurrence during the winter months. Owing to the heavy grade of the stream and the rough and broken character of the topography throughout the basin, its flood waters quickly reach the ocean. Its principal tributaries other than Matilija Creek are San Antonio Creek, which drains a considerable mountain area to the east of Matilija Creek, and Coyote Creek with a small drainage area at a lower elevation to the west. Water is diverted from the main river and its tributaries during the summer months for irrigation and domestic supply in the Ojai Valley and at Ventura.

### MISCELLANEOUS MEASUREMENTS IN VENTURA RIVER DRAINAGE BASIN.

The following is a list of miscellaneous discharge measurements made in the Ventura River drainage basin during 1906:

*Matilija Creek near Matilija, Cal.*—This stream is the principal tributary of the Ventura River. A measurement was made October 24 at the road crossing below Matilija Hot Springs Hotel and above junction of North Fork:

Width, 7 feet; area, 4 square feet; discharge, 7.7 second-feet.

*North Fork Matilija Creek near Matilija, Cal.*—This stream is a tributary of Matilija Creek. A measurement was made October 24 at point 500 feet above its junction with Matilija Creek and above the flume diversion:

Width, 5 feet; area, 1.9 square feet; discharge, 2.2 second-feet.

*San Antonio Creek near Nordhoff, Cal.*—This stream is one of the principal tributaries of Ventura River. A measurement was made October 24 near the crossing of the Nordhoff-Ventura road, 1½ miles below Nordhoff and above the canal diversion:

Width, 8 feet; area, 3.8 square feet; discharge, 4.4 second-feet.

## SANTA YNEZ RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Santa Ynez River rises in the mountains of Santa Barbara and Ventura counties and flows westerly with a flat grade to the Pacific Ocean, having a length of approximately 75 miles. The Santa Ynez Range of mountains, varying in elevation from 3,000 to 4,000 feet, forms

the southern boundary of this drainage basin. The northern divide ranges from 4,500 to 5,500 feet in elevation, culminating in Mount Pinos, the elevation of which is 8,826 feet. The northern part of the watershed is drained by streams running in a southerly direction and uniting with Santa Ynez River proper, which runs close to the northerly base of the Santa Ynez Mountains, flowing westerly and paralleling the Coast Range. The principal tributary, Mono Creek, enters from the north. There are several reservoir sites on Santa Ynez and its tributaries which have been surveyed.

The formation throughout the entire drainage basin consists chiefly of shale and sandstone, the strike being parallel to the coast and the dip nearly vertical, inclining somewhat to the south. The greater portion of the drainage is sparsely covered with brush and small trees, only a small area on the higher elevations having any considerable growth of timber. The mean annual precipitation is estimated at 25 inches for the entire area and falls almost entirely in the form of rain.

### SANTA YNEZ RIVER NEAR SANTA BARBARA, CAL.

This station was established November 1, 1903. It is located at the Gibraltar dam site, 5 miles below the original station, and is below the mouth of Mono Creek. It is 9 miles above the San Marcus ranch and halfway between the old quicksilver mines. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, p. 117, where are given also references to publications that contain data for previous years.

*Discharge measurements of Santa Ynez River near Santa Barbara, Cal., by L. M. Hyde, in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq ft.* | *Feet.* | *Sec.-ft.* |
| January 12 | 16 | 9.0 | 2.10 | 4.7 | March 17[a] | 72 | 216 | 4.30 | 970 |
| January 26 | 20 | 7.7 | 2.18 | 10.1 | March 17[a] | 72 | 201 | 4.10 | 780 |
| February 7 | 18 | 10.0 | 2.21 | 10.1 | March 17[a] | 72 | 216 | 4.30 | 968 |
| February 10 | 18 | 18.3 | 2.40 | 37 | March 17[a] | 72 | 201 | 4.10 | 777 |
| February 11 | 42 | 38 | 2.61 | 63 | March 18[a] | 72 | 172 | 3.74 | 544 |
| February 15 | 75 | 80 | 2.94 | 144 | March 18[a] | 72 | 172 | 3.74 | 534 |
| February 16 | 46 | 38 | 2.53 | 59 | April 17[a] | 62 | 77 | 2.80 | 131 |
| February 24 | 20 | 18 | 2.30 | 24 | June 1 | 32 | 39 | 2.50 | 65 |
| March 14 | 82 | 114 | 3.37 | 291 | June 29 | 25 | 25 | 2.21 | 22 |
| March 15 | 48 | 72 | 3.10 | 189 | July 9 | 13.3 | 11.7 | 2.10 | 8.5 |
| March 16[a] | 80 | 296 | 5.30 | 2,440 | July 27 | 7 | 3.2 | 1.95 | 2.0 |
| March 16[a] | 80 | 414 | 6.70 | 4,170 | August 17 | 6.2 | 1.7 | 1.82 | 1.0 |
| March 16[a] | 80 | 503 | 7.65 | 5,440 | September 24 | 6.5 | 1.7 | 1.82 | 0.7 |
| March 16[a] | 85 | 605 | 8.65 | 6,700 | December 27 | 74 | 150 | 3.90 | 468 |

[a] Measured by floats.

*Daily gage height, in feet, of Santa Ynez River near Santa Barbara, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.0 | 2.15 | 2 25 | 3.6 | 2.55 | 2.5 | 2.2 | 1.95 | 1.8 | 1.8 | 1.8 | 1.9 |
| 2 | 2.0 | 2.1 | 2.25 | 3.55 | 2.5 | 2.5 | 2.2 | 1.95 | 1.8 | 1.8 | 1.8 | 1.9 |
| 3 | 2.05 | 2.1 | 2.25 | 3.5 | 2.5 | 2.45 | 2.2 | 1.9 | 1.8 | 1.8 | 1.8 | 1.9 |
| 4 | 2.05 | 2.1 | 2.8 | 3.4 | 2.5 | 2.45 | 2.15 | 1.9 | 1.8 | 1.8 | 1.8 | 1.9 |
| 5 | 2.05 | 2.1 | 2.5 | 3.3 | 2.5 | 2.4 | 2.15 | 1.9 | 1.8 | 1.8 | 1.8 | 1.9 |
| 6 | 2.05 | 2.2 | 2.4 | 3.3 | 2.45 | 2.4 | 2.15 | 1.9 | 1.8 | 1.8 | 1.8 | 1.9 |
| 7 | 2.05 | 2.2 | 2.35 | 3.2 | 2.45 | 2.4 | 2.1 | 1.9 | 1.8 | 1.8 | 1.85 | 1.9 |
| 8 | 2.05 | 2.2 | 2.3 | 3.1 | 2.45 | 2.35 | 2.1 | 1.9 | 1.8 | 1.8 | 1.85 | 1.9 |
| 9 | 2.05 | 2.15 | 2.3 | 3.1 | 2.45 | 2.35 | 2.1 | 1.9 | 1.8 | 1.8 | 1.85 | 1.95 |
| 10 | 2.05 | 2.3 | 2.3 | 3.05 | 2.45 | 2.35 | 2.1 | 1.85 | 1.8 | 1.8 | 1.85 | 2.1 |
| 11 | 2.05 | 2.6 | 2.3 | 3.05 | 2.4 | 2.3 | 2.1 | 1.85 | 1.8 | 1.8 | 1.85 | 2.25 |
| 12 | 2.1 | 2.4 | 6.4 | 3.0 | 2.4 | 2.3 | 2.1 | 1.85 | 1.8 | 1.8 | 1.85 | 3.85 |
| 13 | 2.15 | 2.2 | 6.0 | 3.0 | 2.4 | 2.3 | 2.1 | 1.85 | 1.8 | 1.8 | 1.85 | 2.5 |
| 14 | 2.25 | 2.4 | 3.7 | 2.9 | 2.4 | 2.3 | 2.1 | 1.85 | 1.8 | 1.8 | 1.85 | 2.4 |
| 15 | 2.25 | 3.05 | 3.05 | 2.8 | 2.4 | 2.3 | 2.1 | 1.85 | 1.8 | 1.8 | 1.85 | 2.3 |
| 16 | 2.25 | 2.5 | 7.2 | 2.8 | 2.4 | 2.3 | 2.1 | 1.8 | 1.8 | 1.8 | 1.85 | 2.2 |
| 17 | 2.25 | 2.4 | 4.2 | 2.8 | 2.4 | 2.25 | 2.1 | 1.8 | 1.8 | 1.8 | 1.85 | 2.2 |
| 18 | 2.25 | 2.35 | 3.65 | 2.75 | 2.35 | 2.25 | 2.1 | 1.8 | 1.8 | 1.8 | 1.85 | 2.15 |
| 19 | 2.8 | 2.3 | 3.35 | 2.75 | 2.35 | 2.25 | 2.1 | 1.8 | 1.8 | 1.8 | 1.85 | 2.1 |
| 20 | 2.5 | 2.3 | 3.15 | 2.7 | 2.35 | 2.25 | 2.05 | 1.8 | 1.8 | 1.8 | 1.85 | 2.1 |
| 21 | 2.35 | 2.4 | 3.1 | 2.7 | 2.35 | 2.25 | 2.05 | 1.8 | 1.8 | 1.8 | 1.85 | 2.1 |
| 22 | 2.3 | 2.4 | 3.0 | 2.7 | 2.35 | 2.25 | 2.05 | 1.8 | 1.8 | 1.8 | 1.85 | 2.05 |
| 23 | 2.3 | 2.3 | 3.85 | 2.7 | 2.35 | 2.25 | 2.0 | 1.8 | 1.8 | 1.8 | 1.85 | 2.05 |
| 24 | 2.25 | 2.3 | 6.6 | 2.7 | 2.35 | 2.25 | 2.0 | 1.8 | 1.8 | 1.8 | 1.85 | 2.05 |
| 25 | 2.25 | 2.3 | 6.75 | 2.65 | 2.35 | 2.25 | 2.0 | 1.8 | 1.8 | 1.8 | 1.85 | 2.05 |
| 26 | 2.2 | 2.3 | 7.1 | 2.65 | 2.5 | 2.2 | 2.0 | 1.8 | 1.8 | 1.8 | 1.85 | 2.6 |
| 27 | 2.15 | 2.25 | 4.9 | 2.6 | 3.15 | 2.2 | 2.0 | 1.8 | 1.8 | 1.8 | 1.85 | 3.35 |
| 28 | 2.15 | 2.25 | 4.4 | 2.6 | 3.9 | 2.2 | 1.95 | 1.8 | 1.8 | 1.8 | 1.85 | 2.8 |
| 29 | 2.15 | ..... | 4.0 | 2.6 | 2.9 | 2.2 | 1.95 | 1.8 | 1.8 | 1.8 | 1.95 | 2.75 |
| 30 | 2.15 | ..... | 3.8 | 2.6 | 2.7 | 2.2 | 1.95 | 1.8 | 1.8 | 1.8 | 1.9 | 2.75 |
| 31 | 2.15 | ..... | 3.7 | ..... | 2.55 | ..... | 1.95 | 1.8 | ..... | 1.8 | ..... | 3.0 |

*Rating table for Santa Ynez River near Santa Barbara, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.80 | 1 | 2.60 | 65 | 3.40 | 315 | 4.40 | 1,065 | 6.00 | 3,070 |
| 1.90 | 2 | 2.70 | 83 | 3.50 | 370 | 4.60 | 1,285 | 6.20 | 3,360 |
| 2.00 | 3 | 2.80 | 104 | 3.60 | 430 | 4.80 | 1,510 | 6.40 | 3,650 |
| 2.10 | 6 | 2.90 | 129 | 3.70 | 495 | 5.00 | 1,750 | 6.60 | 3,940 |
| 2.20 | 12 | 3.00 | 156 | 3.80 | 565 | 5.20 | 1,990 | 6.80 | 4,230 |
| 2.30 | 22 | 3.10 | 186 | 3.90 | 635 | 5.40 | 2,250 | 7.00 | 4,520 |
| 2.40 | 35 | 3.20 | 223 | 4.00 | 710 | 5.60 | 2,510 | 7.20 | 4,810 |
| 2.50 | 49 | 3.30 | 265 | 4.20 | 875 | 5.80 | 2,790 | | |

NOTE.—This table is based on discharge measurements made during 1906 and is fairly well defined.

*Monthly discharge of Santa Ynez River near Santa Barbara, Cal., for 1906.*

[Drainage area, 207 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 104 | 3 | 14.8 | 910 | 0.071 | 0.08 |
| February | 171 | 6 | 27.4 | 1,520 | .132 | .14 |
| March | 4,810 | 17 | 1,050 | 64,600 | 5.07 | 5.84 |
| April | 430 | 65 | 158 | 9,400 | .763 | .85 |
| May | 635 | 28 | 67.4 | 4,140 | .326 | .38 |
| June | 49 | 12 | 23.9 | 1,420 | .115 | .13 |
| July | 12 | 2.5 | 5.7 | 350 | .028 | .03 |
| August | 2.5 | 1.0 | 1.4 | 86 | .0068 | .008 |
| September | 1 | 1 | 1 | 60 | .0048 | .005 |
| October | 1 | 1 | 1 | 61 | .0048 | .006 |
| November | 2.5 | 1 | 1.4 | 83 | .0068 | .008 |
| December | 600 | 2 | 52.1 | 3,200 | .252 | .29 |
| The year | 4,810 | 1 | 117 | 85,800 | .565 | 7.76 |

NOTE.—The above values are fair.

### MISCELLANEOUS MEASUREMENTS IN SANTA YNEZ RIVER DRAINAGE BASIN.

The following miscellaneous discharge measurements were made in the Santa Ynez River drainage basin during 1905 and 1906:

*Santa Ynez River near Lompoc, Cal.*—At the old headworks of the Southern Pacific Milling Company's canal (not in use), 2½ miles above Lompoc, Cal.:

1905—September 25: Width, 21 feet; area, 7.7 square feet; discharge, 8.8 second-feet.

1906—April 19: Width, 97 feet; area, 135 square feet; discharge, 358 second-feet.
July 25: Width, 28 feet; area, 15 square feet; discharge, 21 second-feet.
September 25: Width, 14 feet; area, 6.1 square feet; discharge, 7.1 second-feet.

At the wagon bridge, 1½ miles above Lompoc, Cal.:

1906—November 10: Width, 36 feet; area, 12.8 square feet; discharge, 10 second-feet.
December 12: Width, 107 feet; area, 144 square feet; discharge, 259 second-feet.

## SANTA MARIA RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

The Santa Maria River drains the northern slope of the San Rafael Mountains and a limited area of foothill country to the north of this range. It flows in a westerly direction, finally discharging its waters into the Pacific Ocean at Guadalupe, about 25 miles south of San Luis Obispo. Its flow is torrential in character, subject to floods of short duration during the rainy period, but being practically dry during the summer months. It has numerous tributaries, the most important of which is the Sisquoc, which enters it about 12 miles above the town of Santa Maria. The gaging station is located about 25 miles above the town of Santa Maria and above most of its important tributaries. The country throughout this basin consists of rolling foothills, with the exception of the higher elevations of the San Rafael Mountains, which reach an elevation of 6,000 to 8,000 feet. The river breaks from the foothills at the point where it is joined by the Sisquoc and flows through the flat country of the Santa Maria Valley for a distance of about 25 miles until it joins the Pacific Ocean at Guadalupe. The formation throughout this basin is of shale, sandstone, and conglomerate, with a good covering of heavy clay soil. There is considerable growth of timber on the higher elevations of the San Rafael Mountains, but over most of the area the growth of timber is light, with large areas of brush and grass. The pasturage of stock is carried on extensively throughout the basin. There are no diversions along this stream for irrigation, although tunnel work has been attempted above Santa Maria for the development of underground water, with

poor results. There are numerous wells in the vicinity of Santa Maria which produce considerable water for the irrigation of land in that locality, the soil being very deep and of exceptional quality, susceptible to the highest state of cultivation. The mean precipitation in this drainage basin is probably about 25 inches. The greatest rainfall occurs on the lower elevations near the coast. The higher elevations receive some snowfall, which melts early in the spring and does not tend to keep up the flow of the stream through the summer.

### SANTA MARIA RIVER NEAR SANTA MARIA, CAL.

This station was established October 22, 1903, by W. B. Clapp. It is located near the ranch house on Dutard's ranch, 21 miles above Santa Maria, Cal., a station on the Pacific Coast Railway. It is reached by driving from Santa Maria. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 120, where are given also references to publications that contain data for previous years.

Gage heights observed at this station in 1906 are of no value, therefore no discharges can be computed.

*Discharge measurements of Santa Maria River near Santa Maria, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 23 | R. S. Hawley | 28 | 14.8 | 0.90 | 17.9 |
| June 6 | do | 24 | 12.8 | [a] 2.20 | 11.9 |
| November 7 | do | 20 | 7.0 | 1.70 | 4.9 |

[a] Zero of gage lowered 2 feet.

## SALINAS RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

The Arroyo Seco is the most northern tributary of any size of Salinas River and rises on the slopes of the highest portion of the Santa Lucia Range, one of the ranges that go to make up the Coast Range of California, extending in a general southeast direction from San Francisco Bay. The upper valleys of this stream are far back in the range, surrounded by high mountains.

The drainage area of the Arroyo Seco is almost entirely made up of sharp ridges and V-shaped canyons. The western portion is well covered with brush and trees of medium size. Toward the east this growth decreases until at the Salinas Valley the country is bare. The stream beds of this area fall rapidly, the Arroyo Seco rising at an elevation of nearly 6,000 feet and discharging into the Salinas at an elevation of 170 feet.

Below the gaging station several canals divert water from this stream before it reaches the broad wash of sand and gravel on the flat floor of the Salinas Valley, into which it sinks during the dry season and from which it receives its name, "Arroyo Seco."

On the stream and its tributaries five reservoir sites of more or less value for possible storage have already been surveyed.

This portion of the range undoubtedly receives as great rainfall as any other locality in this region; it is estimated that the average annual precipitation is from 30 to 50 inches and falls almost entirely in the form of rain.

### ARROYO SECO NEAR SOLEDAD, CAL.

The original gaging station on this stream was established by W. W. Cockins, jr., in December, 1900, at Foster's ranch, near Piney, Cal. High water of January, 1901, enlarged an old side channel, dividing the stream into two channels. The gaging station was then removed to Pettitt's ranch, 4 miles below the old station. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 123, where are given also references to publications that contain data for previous years.

*Discharge measurements of Arroyo Seco near Soledad, Cal., by Hawley and Pettitt, in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 24 | 124 | 181 | 6.52 | 396 | April 22 | 122 | 165 | 6.15 | 338 |
| March 6 | 123 | 186 | 6.22 | 436 | April 29 | 121 | 154 | 6.00 | 282 |
| March 9 | 123 | 169 | 6.30 | 388 | May 5 | 120 | 141 | 5.81 | 226 |
| March 11 | 122 | 157 | 6.15 | 328 | May 13 | 120 | 133 | 5.72 | 198 |
| March 13 | 140 | 882 | 11.90 | 5,700 | May 21 | 119 | 121 | 5.60 | 169 |
| March 13 | 130 | 389 | 8.20 | 1,530 | May 28 | 124 | 287 | 7.40 | 1,010 |
| March 15 | 137 | 562 | 10.10 | 3,330 | June 4 | 121 | 154 | 6.00 | 294 |
| March 16 | 136 | 466 | 9.32 | 2,440 | June 5 | 62 | 65 | 5.93 | 269 |
| March 17 | 134 | 405 | 8.45 | 1,790 | June 24 | 75 | 56 | 5.50 | 121 |
| March 18 | 132 | 349 | 7.88 | 1,240 | July 4 | 47 | 67 | 5.35 | 82 |
| March 20 | 128 | 285 | 7.38 | 855 | July 13 | 40 | 47 | 5.25 | 52 |
| March 23 | 135 | 680 | 11.40 | 3,990 | July 29 | 34 | 37 | 5.13 | 28 |
| March 24 | 135 | 446 | 8.75 | 1,900 | August 12 | 31 | 29 | 5.05 | 15.1 |
| March 26 | 133 | 475 | 8.95 | 2,430 | August 26 | 31 | 29 | 5.02 | 18.2 |
| March 30 | 129 | 353 | 8.10 | 1,410 | September 18 | 31 | 28 | 4.90 | 13.5 |
| March 31 | 133 | 496 | 9.25 | 2,510 | October 27 | 18 | 18.8 | 5.01 | 11.2 |
| April 8 | 124 | 244 | 6.95 | 633 | December 31 | 124 | 275 | 7.20 | 83.8 |
| April 15 | 122 | 187 | 6.35 | 414 | | | | | |

*Daily gage height, in feet, of Arroyo Seco near Soledad, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.55 | 5.65 | 6.2 | 8.3 | 5.95 | 6.1 | 5.4 | 5.1 | 4.5 | 5.0 | 5.05 | 5.2 |
| 2 | 5.52 | 5.6 | 6.15 | 8.0 | 5.9 | 6.05 | 5.4 | 5.1 | 4.5 | 5.0 | 5.05 | 5.15 |
| 3 | 5.52 | 5.58 | 6.6 | 7.75 | 5.9 | 6.0 | 5.4 | 5.1 | 4.7 | 5.0 | 5.05 | 5.15 |
| 4 | 5.53 | 5.55 | 8.45 | 7.55 | 5.9 | 6.0 | 5.35 | 5.1 | 4.6 | 5.0 | 5.25 | 5.15 |
| 5 | 5.52 | 5.52 | 6.9 | 7.35 | 5.8 | 5.9 | 5.35 | 5.1 | 4.6 | 5.0 | 5.5 | 5.15 |
| 6 | 5.52 | 5.6 | 6.65 | 7.2 | 5.8 | 5.9 | 5.35 | 5.1 | 4.6 | 5.0 | 5.25 | 5.15 |
| 7 | 5.52 | 5.5 | 6.5 | 7.0 | 5.8 | 5.85 | 5.3 | 5.1 | 4.6 | 4.9 | 5.15 | 5.15 |
| 8 | 5.52 | 5.49 | 6.39 | 6.95 | 5.75 | 5.8 | 5.3 | 5.1 | 4.6 | 4.8 | 5.15 | 5.15 |
| 9 | 5.51 | 5.45 | 6.3 | 6.8 | 5.7 | 5.8 | 5.3 | 5.1 | 4.5 | 4.8 | 5.1 | 5.3 |
| 10 | 5.51 | 5.41 | 6.21 | 6.7 | 5.7 | 5.75 | 5.3 | 5.1 | 4.6 | 4.8 | 5.1 | 5.3 |
| 11 | 5.52 | 5.7 | 6.28 | 6.6 | 5.8 | 5.7 | 5.3 | 5.05 | 4.6 | 4.8 | 5.1 | [a]13.0 |
| 12 | 6.85 | 5.51 | 11.3 | 6.5 | 5.75 | 5.7 | 5.25 | 5.05 | 4.6 | 4.9 | 5.1 | 7.95 |
| 13 | 8.18 | 5.8 | 8.15 | 6.5 | 5.7 | 5.7 | 5.25 | 5.05 | 4.6 | 5.0 | 5.1 | 7.2 |
| 14 | 7.48 | 5.92 | 7.8 | 6.4 | 5.7 | 5.65 | 5.25 | 5.05 | 4.6 | 5.0 | 5.1 | 6.6 |
| 15 | 7.30 | 7.05 | 10.1 | 6.35 | 5.7 | 5.65 | 5.2 | 5.0 | 4.7 | 5.0 | 5.1 | 6.2 |
| 16 | 6.75 | 6.45 | 9.25 | 6.3 | 5.7 | 5.6 | 5.2 | 5.0 | 4.7 | 5.0 | 5.1 | 6.1 |
| 17 | 7.98 | 6.3 | 8.4 | 6.3 | 5.65 | 5.6 | 5.2 | 5.0 | 4.8 | 5.0 | 5.1 | 5.85 |
| 18 | 7.98 | 6.28 | 7.88 | 6.2 | 5.6 | 5.6 | 5.2 | 5.0 | 4.9 | 5.0 | 5.1 | 5.8 |
| 19 | 10.12 | 6.18 | 7.6 | 6.2 | 5.6 | 5.55 | 5.2 | 5.0 | 4.9 | 5.0 | 5.1 | 5.7 |
| 20 | 8.0 | 6.1 | 7.3 | 6.2 | 5.6 | 5.5 | 5.2 | 5.0 | 5.0 | 5.0 | 5.1 | 5.6 |
| 21 | 7.2 | 6.3 | 7.95 | 6.2 | 5.6 | 5.5 | 5.2 | 5.0 | 5.0 | 5.0 | 5.1 | 5.55 |
| 22 | 6.8 | 6.85 | 7.48 | 6.2 | 5.6 | 5.5 | 5.2 | 5.05 | 5.0 | 5.05 | 5.15 | 5.5 |
| 23 | 6.5 | 6.6 | 8.94 | 6.2 | 5.6 | 5.5 | 5.2 | 5.05 | 5.0 | 5.05 | 5.15 | 5.5 |
| 24 | 6.3 | 6.59 | 8.85 | 6.2 | 5.6 | 5.5 | 5.2 | 5.05 | 5.0 | 5.05 | 5.1 | 5.5 |
| 25 | 6.15 | 6.49 | 8.7 | 6.2 | 5.6 | 5.5 | 5.2 | 5.05 | 5.05 | 5.05 | 5.15 | 5.5 |
| 26 | 6.0 | 6.39 | 9.0 | 6.05 | 6.55 | 5.5 | 5.15 | 5.0 | 5.05 | 5.05 | 5.15 | 7.45 |
| 27 | 5.95 | 6.3 | 8.35 | 6.05 | 8.3 | 5.5 | 5.1 | 5.0 | 5.05 | 5.05 | 5.15 | 7.2 |
| 28 | 5.9 | 6.3 | 8.0 | 6.0 | 7.3 | 5.5 | 5.1 | 4.9 | 5.05 | 5.05 | 5.15 | 6.7 |
| 29 | 5.85 | ..... | 7.7 | 6.0 | 6.75 | 5.45 | 5.15 | 4.8 | 5.0 | 5.05 | 5.2 | 6.35 |
| 30 | 5.75 | ..... | 8.12 | 6.0 | 6.45 | 5.4 | 5.1 | 4.7 | 5.0 | 5.05 | 5.2 | 6.25 |
| 31 | 5.7 | ..... | 9.08 | ..... | 6.4 | ..... | 5.1 | 4.6 | ..... | 5.05 | ..... | 7.2 |

[a] Estimated.

*Rating table for Arroyo Seco near Soledad, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 4.50 | 0 | 5.60 | 153 | 6.70 | 553 | 7.80 | 1,195 | 9.80 | 2,980 |
| 4.60 | 1 | 5.70 | 185 | 6.80 | 599 | 7.90 | 1,265 | 10.00 | 3,180 |
| 4.70 | 3 | 5.80 | 218 | 6.90 | 648 | 8.00 | 1,340 | 10.20 | 3,380 |
| 4.80 | 5 | 5.90 | 252 | 7.00 | 700 | 8.20 | 1,495 | 10.40 | 3.580 |
| 4.90 | 8 | 6.00 | 286 | 7.10 | 754 | 8.40 | 1,660 | 10.60 | 3,780 |
| 5.00 | 14 | 6.10 | 320 | 7.20 | 810 | 8.60 | 1.840 | 10.80 | 3,980 |
| 5.10 | 24 | 6.20 | 356 | 7.30 | 868 | 8.80 | 2,020 | 11.00 | 4,180 |
| 5.20 | 40 | 6.30 | 393 | 7.40 | 928 | 9.00 | 2,200 | 12.00 | 5,180 |
| 5.30 | 63 | 6.40 | 431 | 7.50 | 990 | 9.20 | 2,390 | 13.00 | 6.250 |
| 5.40 | 91 | 6.50 | 470 | 7.60 | 1,055 | 9.40 | 2,580 | | |
| 5.50 | 121 | 6.60 | 510 | 7.70 | 1,125 | 9.60 | 2,780 | | |

NOTE.—This table is based on 35 discharge measurements made during 1906 and is well defined between gage heights 5 feet and 10 feet.

*Monthly discharge of Arroyo Seco near Soledad, Cal., for 1906.*

[Drainage area, 215 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 3,300 | 124 | 556 | 34,200 | 2.59 | 2.99 |
| February | 727 | 94 | 302 | 16,800 | 1.41 | 1.47 |
| March | 4,480 | 338 | 1,360 | 83,600 | 6.32 | 7.29 |
| April | 1,580 | 286 | 558 | 33,200 | 2.60 | 2.90 |
| May | 1,580 | 153 | 297 | 18,300 | 1.38 | 1.59 |
| June | 320 | 91 | 178 | 10,600 | .828 | .92 |
| July | 91 | 24 | 50.8 | 3,120 | .236 | .27 |
| August | 24 | 1 | 17.3 | 1,060 | .080 | .09 |
| September | 19 | 0 | 7.1 | 422 | .033 | .04 |
| October | 19 | 5 | 14.1 | 867 | .066 | .08 |
| November | 121 | 19 | 31.8 | 1,890 | .148 | .16 |
| December | 6,250 | 32 | 492 | 30,300 | 2.29 | 2.64 |
| The year | 6,250 | 0 | 322 | 234,000 | 1.49 | 20.44 |

NOTE.—Values are rated as follows: January to June, excellent; July and December, good; August to November, fair.

## SAN FRANCISCO BAY DRAINAGE BASIN.

### GENERAL FEATURES.

Sacramento River, rising in northern California and flowing south, and San Joaquin River, rising in the southern Sierras and flowing north, drain the western slope of the Sierra Nevada and the eastern slope of the Coast Range north of San Francisco. They meet near Suisun Bay, finally discharging their waters into the Pacific Ocean through San Francisco Bay.

### SACRAMENTO RIVER DRAINAGE BASIN.

#### DESCRIPTION OF BASIN.

Sacramento River is the principal river of California, and drains all of the territory south of Mount Shasta and between the Coast Range and Trinity Range on the west and the Sierra Nevada on the east. The portion of the drainage basin above Red Bluff, Cal., extends from the Trinity Mountains on the west to Warner Mountains near the California-Nevada State line on the east. The watershed on the west from the Trinity Mountains is comparatively narrow, being only from 10 to 35 miles in width, and furnishes a very small proportion of the discharge of this river, but from the east Pit River, which is the most important tributary, drains a large area extending about 120 miles east from Sacramento River between Mount Shasta on the north and Lassen Peak on the south. The greater portion of this basin is composed of lava and shows other evidences of volcanic activity, such as volcanic cones and craters. Nearly all the streams tributary to Pit River have their origin in large springs, many of which discharge several hundred second-feet. The most

important tributary of the Pit is McCloud River, draining the southeastern slope of Mount Shasta. It derives its waters principally from the melting of the snow on the high elevations of this mountain. The western portion of the watershed extending along the Trinity Range is well timbered, as is also that portion of the drainage area in the Sierra Nevada lying between Mount Shasta and Lassen Peak. Farther east, however, there is little or no forest covering, and the country is used extensively for pasturage. The rainfall is very unequally distributed, varying from less than 10 inches in the eastern portion of the basin to 50 inches along the northern and western portion. Below the gaging station the river enters the Sacramento Valley, through which it flows on a comparatively light grade until it reaches Suisun Bay. During the winter months, when the Sacramento and its tributaries are in flood, large areas of the Sacramento Valley are overflowed. The floods that occur in the latter part of the rainy season, after the large overflow areas or basins are filled, cause great damage in the lower portion of the valley.

## MAIN SACRAMENTO RIVER.

### SACRAMENTO RIVER NEAR RED BLUFF, CAL.

The gaging station at Jellys Ferry, which is located about 12 miles above the town of Red Bluff, was established April 30, 1895. The right bank of the river is high, but the left bank is liable to overflow when the river rises above the 25-foot mark. The river has been known to reach the 35-foot mark. Because of the liability to overflow it was deemed advisable to select a new gaging station, where the water at flood stage could be more confined. A point in Iron Canyon, where the river had been gaged by the State engineering department in 1879 and by commissioner of public works in 1893–94, was chosen as a new gaging station. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, p. 128, where are given also references to publications that contain data for previous years.

*Discharge measurements of Sacramento River near Red Bluff, Cal., by R. S. Hawley, in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 27 | 550 | 8,230 | 10.30 | 41,600 | May 16 | 529 | 5,290 | 4.64 | 15,700 |
| February 27 | 546 | 7,850 | 9.45 | 36,000 | May 18 | 527 | 4,980 | 4.14 | 13,800 |
| March 13 | 550 | 7,920 | 9.60 | 38,200 | June 12 | 534 | 6,270 | 6.50 | 23,900 |
| March 14 | 550 | 7,780 | 9.30 | 36,900 | June 13 | 532 | 5,890 | 5.68 | 19,600 |
| March 26[a] | 590 | 12,900 | 18.30 | 92,900 | July 7 | 520 | 4,360 | 2.90 | 9,900 |
| April 11 | 536 | 6,550 | 7.00 | 24,500 | September 6 | 496 | 3,330 | 1.63 | 5,470 |
| May 3 | 531 | 5,570 | 5.25 | 18,500 | December 11 | 538 | 6,570 | 7.60 | 26,900 |

[a] Measured by floats.

*Daily gage height, in feet, of Sacramento River near Red Bluff, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.5 | 2.9 | 7.65 | 15.5 | 5.5 | 5.6 | 3.3 | 1.9 | 1.7 | 1.6 | 1.6 | 1.7 |
| 2 | 1.4 | 2.8 | 6.95 | 12.55 | 5.4 | 5.5 | 3.25 | 1.9 | 1.65 | 1.6 | 1.6 | 1.7 |
| 3 | 1.4 | 2.7 | 10.65 | 10.75 | 5.3 | 5.5 | 3.2 | 1.9 | 1.65 | 1.6 | 1.85 | 1.65 |
| 4 | 1.4 | 2.7 | 10.75 | 9.6 | 5.2 | 8.85 | 3.1 | 1.9 | 1.65 | 1.55 | 2.4 | 1.7 |
| 5 | 1.4 | 2.6 | 8.2 | 8.55 | 5.3 | 7.75 | 3.0 | 1.9 | 1.65 | 1.55 | 3.25 | 1.7 |
| 6 | 1.45 | 2.55 | 7.3 | 7.9 | 5.15 | 7.8 | 2.95 | 1.8 | 1.65 | 1.55 | 2.2 | 1.75 |
| 7 | 1.45 | 2.5 | 6.9 | 7.5 | 5.0 | 6.85 | 2.9 | 1.8 | 1.6 | 1.55 | 2.0 | 2.35 |
| 8 | 1.45 | 2.5 | 6.6 | 7.3 | 4.9 | 6.2 | 2.8 | 1.8 | 1.6 | 1.55 | 1.9 | 2.35 |
| 9 | 1.5 | 2.6 | 6.6 | 7.25 | 4.8 | 6.0 | 2.8 | 1.8 | 1.6 | 1.55 | 1.85 | 2.4 |
| 10 | 1.8 | 2.7 | 6.5 | 7.1 | 4.9 | 5.6 | 2.7 | 1.75 | 1.6 | 1.55 | 1.8 | 5.2 |
| 11 | 1.75 | 3.25 | 6.45 | 6.9 | 4.8 | 5.35 | 2.7 | 1.75 | 1.6 | 1.55 | 1.8 | 7.75 |
| 12 | 3.3 | 3.9 | 14.85 | 6.55 | 4.7 | 6.35 | 2.6 | 1.75 | 1.6 | 1.55 | 1.75 | 7.3 |
| 13 | 4.65 | ..... | 9.9 | 6.2 | 4.55 | 5.6 | 2.6 | 1.7 | 1.6 | 1.55 | 1.75 | 5.0 |
| 14 | 4.3 | 3.35 | 9.55 | 6.5 | 4.55 | 5.25 | 2.5 | 1.7 | 1.75 | 1.55 | 1.75 | 3.85 |
| 15 | 4.35 | 10.95 | 7.75 | 5.9 | 4.9 | 5.0 | 2.5 | 1.7 | 1.7 | 1.6 | 1.8 | 3.15 |
| 16 | 12.8 | 7.45 | 7.0 | 5.8 | 4.6 | 5.9 | 2.4 | 1.7 | 1.7 | 1.6 | 1.8 | 3.0 |
| 17 | 9.85 | 7.3 | 6.6 | 5.8 | 4.3 | 5.4 | 2.4 | 1.7 | 1.65 | 1.6 | 1.8 | 2.85 |
| 18 | 12.7 | 6.75 | 5.95 | 5.75 | 4.2 | 5.0 | 2.4 | 1.65 | 1.65 | 1.6 | 1.75 | 2.8 |
| 19 | 22.6 | 10.6 | 5.35 | 5.6 | 4.1 | 4.05 | 2.3 | 1.7 | 1.6 | 1.6 | 1.7 | 2.6 |
| 20 | 9.1 | 8.5 | 5.85 | 5.6 | 4.0 | 4.5 | 2.3 | 1.7 | 1.6 | 1.6 | 1.7 | 2.4 |
| 21 | 5.8 | 9.9 | 8.3 | 5.7 | 4.0 | 4.3 | 2.25 | 1.7 | 1.6 | 1.55 | 1.7 | 2.4 |
| 22 | 4.7 | 10.0 | 12.95 | 5.75 | 3.9 | 4.1 | 2.2 | 1.75 | 1.6 | 1.6 | 1.7 | 2.3 |
| 23 | 4.3 | 12.75 | 10.7 | 6.0 | 3.8 | 3.95 | 2.2 | 1.75 | 1.65 | 1.6 | 1.7 | 2.3 |
| 24 | 4.0 | 11.5 | 14.85 | 5.8 | 3.7 | 3.75 | 2.1 | 1.7 | 1.7 | 1.6 | 1.7 | 2.65 |
| 25 | 3.75 | 10.35 | 16.6 | 6.1 | 4.4 | 3.7 | 2.1 | 1.7 | 1.7 | 1.6 | 1.7 | 4.8 |
| 26 | 3.55 | 8.4 | 17.95 | 5.5 | 9.6 | 3.6 | 2.1 | 1.7 | 1.6 | 1.6 | 1.7 | 12.7 |
| 27 | 3.4 | 9.1 | 15.45 | 6.0 | 11.0 | 3.75 | 2.0 | 1.7 | 1.6 | 1.6 | 1.7 | 13.65 |
| 28 | 3.4 | 8.5 | 12.6 | 6.2 | 10.6 | 3.7 | 2.0 | 1.7 | 1.6 | 1.6 | 1.65 | 8.55 |
| 29 | 3.25 | ..... | 10.8 | 5.6 | 8.95 | 3.5 | 2.0 | 1.7 | 1.6 | 1.6 | 1.7 | 6.5 |
| 30 | 3.2 | ..... | 12.85 | 5.55 | 7.35 | 3.35 | 2.0 | 1.7 | 1.6 | 1.6 | 1.7 | 5.3 |
| 31 | 3.05 | ..... | 23.35 | ..... | 6.5 | ..... | 1.9 | 1.7 | ..... | 1.6 | ..... | 6.0 |

*Rating table for Sacramento River near Red Bluff, Cal., for 1904–1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.40 | 5,410 | 2.60 | 8,810 | 3.80 | 12,720 | 6.00 | 21,100 | 14.00 | 61,700 |
| 1.50 | 5,650 | 2.70 | 9,120 | 3.90 | 13,060 | 6.20 | 21,940 | 15.00 | 68,200 |
| 1.60 | 5,920 | 2.80 | 9,430 | 4.00 | 13,400 | 6.40 | 22,780 | 16.00 | 75,100 |
| 1.70 | 6,190 | 2.90 | 9,740 | 4.20 | 14,120 | 6.60 | 23,620 | 17.00 | 82,200 |
| 1.80 | 6,460 | 3.00 | 10,050 | 4.40 | 14,840 | 6.80 | 24,460 | 18.00 | 89,700 |
| 1.90 | 6,730 | 3.10 | 10,380 | 4.60 | 15,580 | 7.00 | 25,300 | 19.00 | 97,600 |
| 2.00 | 7,000 | 3.20 | 10,710 | 4.80 | 16,340 | 8.00 | 29,700 | 20.00 | 105,900 |
| 2.10 | 7,300 | 3.30 | 11,040 | 5.00 | 17,100 | 9.00 | 34,300 | 21.00 | 114,600 |
| 2.20 | 7,600 | 3.40 | 11,370 | 5.20 | 17,900 | 10.00 | 39,100 | 22.00 | 123,700 |
| 2.30 | 7,900 | 3.50 | 11,700 | 5.40 | 18,700 | 11.00 | 44,200 | 23.00 | 133,200 |
| 2.40 | 8,200 | 3.60 | 12,040 | 5.60 | 19,500 | 12.00 | 49,700 | 24.00 | 143,100 |
| 2.50 | 8,500 | 3.70 | 12,380 | 5.80 | 20,300 | 13.00 | 55,600 | | |

NOTE.—This table is based on discharge measurements made during 1902–1906 and is well defined.

*Monthly discharge of Sacramento River near Red Bluff, Cal., for 1906.*

[Drainage area, 9,300 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 129,000 | 5,410 | 14,700 | 904,000 | 1.58 | 1.82 |
| February | 54,100 | 8,500 | 23,200 | 1,290,000 | 2.49 | 2.59 |
| March | 137,000 | 18,500 | 42,500 | 2,610,000 | 4.57 | 5.27 |
| April | 71,600 | 19,100 | 26,300 | 1,560,000 | 2.83 | 3.16 |
| May | 44,200 | 12,400 | 19,400 | 1,190,000 | 2.09 | 2.41 |
| June | 33,600 | 11,200 | 18,100 | 1,080,000 | 1.95 | 2.18 |
| July | 11,000 | 6,730 | 8,530 | 524,000 | .917 | 1.06 |
| August | 6,730 | 6,060 | 6,330 | 389,000 | .681 | .79 |
| September | 6,320 | 5,920 | 6,020 | 358,000 | .647 | .72 |
| October | 5,920 | 5,780 | 5,870 | 361,000 | .631 | .73 |
| November | 10,900 | 5,920 | 6,570 | 391,000 | .706 | .79 |
| December | 59,500 | 6,060 | 15,400 | 947,000 | 1.66 | 1.91 |
| The year | 137,000 | 5,410 | 16,100 | 11,600,000 | 1.73 | 23.43 |

NOTE.—These values are excellent.

### MISCELLANEOUS MEASUREMENT IN SACRAMENTO RIVER DRAINAGE BASIN.

The following measurement was made of Sacramento River at Baird station, on the Southern Pacific Railway, near Gregory, Cal., October 9, 1906:

Width, 115 feet; area, 300 square feet; discharge, 315 second-feet.

## PIT RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Pit River has its source in the Warner Mountains in the extreme northeast part of California. It flows in a southwesterly direction, discharging its waters into Sacramento River a few miles above Redding, Cal. It has numerous tributaries, the larger of which have their source in large springs, which discharge from crevices in the lava formation. About 50 per cent of the area of this drainage basin is barren of timber and composed principally of lava with a light soil covering, being used extensively for pasturage and the raising of stock. There are numerous small valleys with light grades, which hold the water throughout the summer months principally in the state of swamps. These areas are used mainly as meadow land and for the raising of stock feed. Pit River does not discharge in any great volume until it reaches a point near Fall River Mills, which lies about midway between the point where the Pit River enters the Sacramento and its source. Fall River, which is the principal tributary of the Pit from the north, receives its water supply from large perennial springs which discharge 1,500 second-feet. Hat Creek and Burney Creek are also large tributaries from the south and drain the northern slope of Lassen Peak. Their principal sources are also from large perennial springs in the lava formation.

West Valley Creek is a tributary of South Fork of Pit River. Ash Creek flows into Clear Creek, through which it enters Pit River from the south. There is considerable timber scattered throughout this drainage basin, the principal growth lying in the southern portion of the basin and also in that section lying north of Pit River and between Fall River and the upper Sacramento. There are numerous reservoir sites on the upper reaches of this stream, all of which have been or are being surveyed. Several gaging stations are maintained on Pit River and tributaries at points where surveys have been made for the construction of storage reservoirs. The rainfall throughout this basin is very unevenly distributed, ranging from 10 inches in the eastern portion to 50 to 75 inches in the western and northwestern portion. About 50 per cent of the precipitation falls in the form of snow, but does not remain any length of time except on the higher elevation of Mount Shasta and Lassen Peak.

McCloud River drains the southeastern slope of Mount Shasta. Its drainage area is comparatively small, covering 676 square miles. It is long and narrow, extending from north to south. There are few tributaries. Its main water supply comes from Mount Shasta, on which the snow remains during the entire year. It is also fed by numerous large springs scattered throughout the drainage basin. The precipitation is very heavy and is principally in the form of rain, except on the higher elevations of Mount Shasta. The discharge of this stream seldom falls below 1,200 second-feet. It discharges into the Pit River a few miles above the junction of the Pit with the Sacramento. The entire basin is well timbered.

### PIT RIVER NEAR BIEBER, CAL.

This station was established January 22, 1904. It is located 12 miles below Bieber, Cal., near Muck Valley. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 136, where are given also references to publications that contain data for previous years.

*Discharge measurements of Pit River near Bieber, Cal., by F. H. Holabird, in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 29[a] | 213 | 870 | 5.90 | 1,820 | April 9 | 224 | 1,100 | 6.90 | 3,350 |
| February 3[a] | 209 | 680 | 5.00 | 1,320 | April 12 | 220 | 986 | 6.40 | 2,580 |
| February 5[a] | 209 | 680 | 5.00 | 1,180 | April 13 | 219 | 942 | 6.20 | 2,340 |
| February 8[a] | 207 | 615 | 4.70 | 938 | April 14 | 219 | 917 | 6.10 | 2,190 |
| February 10[a] | 207 | 615 | 4.70 | 877 | April 15 | 214 | 870 | 5.90 | 1,880 |
| February 12 | 205 | 637 | 4.80 | 983 | April 17 | 217 | 853 | 5.80 | 1,870 |
| February 14 | 207 | 723 | 5.20 | 1,310 | April 19 | 214 | 826 | 5.70 | 1,780 |
| February 16 | 220 | 962 | 6.30 | 2,660 | April 20 | 210 | 807 | 5.60 | 1,700 |
| February 17 | 219 | 942 | 6.20 | 2,430 | April 27 | 207 | 740 | 5.32 | 1,440 |
| February 19 | 220 | 987 | 6.40 | 2,690 | May 5 | 207 | 616 | 4.70 | 933 |
| February 21 | 220 | 1,050 | 6.70 | 3,190 | May 12 | 207 | 616 | 4.70 | 906 |
| February 23 | 224 | 1,100 | 6.90 | 3,530 | May 19 | 207 | 660 | 4.90 | 1,080 |
| February 26 | 220 | 942 | 6.20 | 2,420 | May 26 | 207 | 596 | 4.60 | 858 |
| February 28 | 224 | 1,120 | 7.04 | 3,680 | June 2 | 207 | 573 | 4.50 | 773 |
| March 8 | 215 | 892 | 6.00 | 2,090 | June 9 | 193 | 512 | 4.35 | 657 |
| March 12 | 224 | 1,150 | 7.10 | 3,640 | June 16 | 193 | 473 | 4.10 | 525 |
| March 13 | 230 | 1,270 | 7.65 | 4,610 | August 11 | 98 | 176 | 2.30 | 64 |
| March 18 | 219 | 942 | 6.25 | 2,380 | August 25 | 68 | 128 | 1.80 | 20 |
| March 20 | 219 | 942 | 6.20 | 2,390 | September 1 | 68 | 128 | 1.80 | 20 |
| March 21 | 222 | 985 | 6.50 | 2,760 | September 8 | 68 | 128 | 1.80 | 19 |
| March 22 | 224 | 1,210 | 7.52 | 4,340 | September 15 | 68 | 132 | 1.90 | 27 |
| March 23[b] | | 1,680 | 9.50 | 9,500 | September 23 | 68 | 137 | 2.00 | 29 |
| April 4 | 224 | 1,190 | 7.30 | 3,930 | September 29 | 68 | 128 | 1.85 | 24 |
| April 5 | 224 | 1,100 | 6.90 | 3,330 | October 7 | 68 | 130 | 1.90 | 25 |
| April 6 | 224 | 1,080 | 6.85 | 3,260 | October 14 | 68 | 141 | 2.00 | 29 |
| April 7 | 224 | 1,100 | 6.90 | 3,280 | October 26 | 98 | 208 | 2.60 | 81 |
| April 8 | 224 | 1,100 | 6.95 | 3,310 | | | | | |

[a] Measured by Toler and Holabird.
[b] Velocities not measured in entire cross section; discharge probably too great.

*Daily gage height, in feet, of Pit River near Bieber, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 5.5 | 6.7 | 9.1 | 5.1 | 4.5 | 4.1 | 2.6 | 1.8 | 1.85 |
| 2 | ..... | 5.0 | 6.5 | 8.3 | 5.1 | 4.5 | 4.0 | 2.6 | 1.8 | 1.85 |
| 3 | ..... | 5.0 | 6.3 | 7.8 | 4.9 | 4.5 | 4.0 | 2.6 | 1.8 | 1.9 |
| 4 | ..... | 5.0 | 6.05 | 7.3 | 4.8 | 4.5 | 3.8 | 2.6 | 1.8 | 1.9 |
| 5 | ..... | 5.0 | 6.1 | 6.9 | 4.7 | 4.5 | 3.8 | 2.6 | 1.8 | 1.9 |
| 6 | ..... | 4.8 | 6.0 | 6.85 | 4.7 | 4.4 | 3.8 | 2.6 | 1.8 | 1.9 |
| 7 | ..... | 4.7 | 6.0 | 6.9 | 4.7 | 4.4 | 3.8 | 2.5 | 1.8 | 1.9 |
| 8 | ..... | 4.7 | 6.0 | 6.95 | 4.7 | 4.4 | 3.85 | 2.5 | 1.8 | 1.9 |
| 9 | ..... | 4.7 | 6.4 | 6.9 | 4.7 | 4.35 | 3.85 | 2.4 | ..... | 1.9 |
| 10 | ..... | 4.7 | 6.8 | 6.8 | 4.7 | 4.3 | 3.7 | 2.3 | ..... | 2.0 |
| 11 | ..... | 4.7 | 7.0 | 6.5 | 4.7 | 4.3 | 3.7 | 2.3 | ..... | 2.0 |
| 12 | ..... | 4.8 | 7.1 | 6.4 | 4.7 | 4.2 | 3.7 | 2.3 | ..... | 2.0 |
| 13 | ..... | 5.1 | 7.6 | 6.2 | 4.8 | 4.2 | 3.7 | 2.3 | ..... | 2.0 |
| 14 | ..... | 5.2 | 7.1 | 6.1 | 4.9 | 4.2 | 3.5 | 2.9 | ..... | ..... |
| 15 | 3.45 | 5.8 | 6.8 | 6.0 | 4.9 | 4.2 | 3.5 | 2.9 | 1.9 | ..... |
| 16 | 4.35 | 6.3 | 6.3 | 5.9 | 4.8 | 4.1 | 3.5 | 2.6 | 1.9 | ..... |
| 17 | 4.25 | 6.2 | 6.1 | 5.8 | 4.8 | 4.1 | 3.4 | 2.4 | 2.0 | ..... |
| 18 | 4.6 | 6.2 | 6.2 | 5.8 | 4.8 | 4.0 | 3.4 | 2.2 | 2.0 | ..... |
| 19 | 5.8 | 6.4 | 6.4 | 5.7 | 4.9 | 4.0 | 3.35 | 2.2 | 2.0 | ..... |
| 20 | 6.4 | 6.4 | 6.2 | 5.6 | 4.9 | 3.5 | 3.35 | ..... | 1.9 | ..... |
| 21 | 6.4 | 6.7 | 6.4 | 5.5 | 4.9 | 3.4 | 3.3 | ..... | 1.9 | ..... |
| 22 | 6.8 | 7.2 | 7.4 | 5.5 | 4.8 | 3.35 | ..... | ..... | 1.9 | ..... |
| 23 | 7.3 | 6.9 | 9.5 | 5.4 | 4.65 | 3.55 | ..... | ..... | 2.0 | ..... |
| 24 | 7.8 | 6.7 | 10.5 | 5.4 | 4.65 | 3.55 | ..... | ..... | 2.0 | ..... |
| 25 | 6.0 | 6.5 | 11.5 | 5.2 | 4.6 | 4.2 | ..... | 1.8 | 2.0 | ..... |
| 26 | 6.0 | 6.2 | 11.0 | 5.2 | 4.6 | 4.2 | ..... | 1.8 | 1.9 | ..... |
| 27 | 6.1 | 6.4 | 10.2 | 5.3 | 4.6 | 4.2 | ..... | 1.8 | 1.9 | ..... |
| 28 | 6.1 | 7.0 | 9.3 | 5.3 | 4.6 | 4.2 | ..... | 1.8 | 1.9 | ..... |
| 29 | 6.1 | ..... | 8.6 | 5.2 | 4.6 | 4.2 | ..... | 1.8 | 1.85 | ..... |
| 30 | 6.0 | ..... | 8.2 | 5.15 | 4.6 | 4.1 | ..... | 1.8 | 1.85 | ..... |
| 31 | 5.8 | ..... | 8.4 | ..... | 4.6 | ..... | ..... | 1.8 | ..... | ..... |

*Rating table for Pit River near Bieber, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* |
| 1.80 | 21 | 2.90 | 108 | 4.00 | 450 | 5.00 | 1,140 | 7.00 | 3,520 |
| 1.90 | 24 | 3.00 | 120 | 4.10 | 500 | 5.20 | 1,320 | 7.20 | 3,840 |
| 2.00 | 29 | 3.10 | 135 | 4.20 | 560 | 5.40 | 1,500 | 7.40 | 4,160 |
| 2.10 | 35 | 3.20 | 154 | 4.30 | 620 | 5.60 | 1,700 | 7.60 | 4,480 |
| 2.20 | 41 | 3.30 | 177 | 4.40 | 685 | 5.80 | 1,900 | 7.80 | 4,820 |
| 2.30 | 49 | 3.40 | 205 | 4.50 | 755 | 6.00 | 2,120 | 8.00 | 5,180 |
| 2.40 | 57 | 3.50 | 240 | 4.60 | 825 | 6.20 | 2,360 | 9.00 | 7,140 |
| 2.50 | 66 | 3.60 | 276 | 4.70 | 900 | 6.40 | 2,630 | 10.00 | 9,600 |
| 2.60 | 76 | 3.70 | 316 | 4.80 | 980 | 6.60 | 2,920 | 11.00 | 12,400 |
| 2.70 | 86 | 3.80 | 356 | 4.90 | 1,060 | 6.80 | 3,220 | 12.00 | 15,200 |
| 2.80 | 96 | 3.90 | 400 | | | | | | |

NOTE.—This table is based on 53 discharge measurements made during 1906 and is well defined below gage height 7.5 feet.

*Monthly discharge of Pit River near Bieber, Cal., for 1906.*

[Drainage area, 2,950 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January (15–31) | 4,820 | 222 | 2,150 | 72,500 | 0.728 | 0.46 |
| February | 3,840 | 900 | 1,930 | 107,000 | .654 | .68 |
| March | 13,800 | 2,120 | 4,640 | 285,000 | 1.57 | 1.81 |
| April | 7,360 | 1,280 | 2,590 | 154,000 | .878 | .98 |
| May | 1,230 | 825 | 948 | 58,300 | .321 | .37 |
| June | 755 | 190 | 544 | 32,400 | .184 | .21 |
| July (1–21) | 500 | 177 | 311 | 13,000 | .105 | .08 |
| August | 108 | 21 | [a] 51 | 3,140 | .017 | .02 |
| September | 29 | 21 | [a] 24 | 1,430 | .008 | .009 |
| October (1–13) | 29 | 22 | 25 | 645 | .008 | .004 |
| The period | ..... | ..... | ..... | 727,000 | ..... | ..... |

[a] Discharges interpolated for days when gage was not read.

NOTE.—Values are rated as follows: January to June, excellent; July, good; August to October, fair.

## M'CLOUD RIVER NEAR GREGORY, CAL.

This station was established March 23, 1902, in cooperation with the McCloud River Electric Company. It is located at Johns Camp, near Hirze Mountain, 14 miles east of Gregory post-office, Cal. Baird Station, on the Southern Pacific Railroad, is just across Sacramento River from Gregory. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 147, where are given also references to publications that contain data for previous years.

*Discharge measurements of McCloud River near Gregory, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 16[a] | F. P. Ackerson | 143 | 1,080 | 6.05 | 8,780 |
| January 16[a] | do | 152 | 1,330 | 7.40 | 12,400 |
| February 12 | R. S. Hawley | 104 | 556 | 1.90 | 1,580 |
| April 12 | do | 105 | 685 | 3.07 | 2,910 |
| May 17 | do | 104 | 637 | 2.45 | 2,360 |
| October 10 | do | 100 | 576 | 1.56 | 1,340 |

[a] Measured by floats.

*Daily gage height, in feet, of McCloud River near Gregory, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.6 | 1.85 | 3.3 | 5.6 | 2.85 | 3.6 | 2.3 | 1.8 | 1.6 | 1.6 | 1.55 | 1.55 |
| 2 | 1.6 | 1.85 | 3.3 | 4.6 | 2.8 | 3.6 | 2.25 | 1.8 | 1.6 | 1.6 | 1.6 | 1.55 |
| 3 | 1.55 | 1.85 | 3.55 | 4.15 | 2.8 | 4.65 | 2.25 | 1.8 | 1.6 | 1.6 | 1.7 | 1.55 |
| 4 | 1.55 | 1.8 | 3.3 | 3.75 | 2.8 | 6.5 | 2.2 | 1.8 | 1.6 | 1.6 | 2.35 | 1.56 |
| 5 | 1.55 | 1.8 | 3.0 | 3.5 | 2.75 | 5.65 | 2.2 | 1.8 | 1.6 | 1.6 | 1.75 | 1.5 |
| 6 | 1.55 | 1.8 | 2.75 | 3.4 | 2.7 | 5.35 | 2.15 | 1.8 | 1.6 | 1.6 | 1.6 | 1.5 |
| 7 | 1.55 | 1.75 | 2.8 | 3.3 | 2.7 | 4.6 | 2.2 | 1.8 | 1.6 | 1.6 | 1.6 | 1.5 |
| 8 | 1.55 | 1.75 | 2.85 | 3.3 | 2.7 | 4.1 | 2.15 | 1.8 | 1.6 | 1.6 | 1.55 | 1.65 |
| 9 | 1.55 | 1.8 | 2.9 | 3.3 | 2.65 | 3.9 | 2.1 | 1.75 | 1.6 | 1.6 | 1.55 | 2.0 |
| 10 | 1.6 | 1.9 | 2.85 | 3.3 | 2.65 | 3.8 | 2.1 | 1.75 | 1.6 | 1.55 | 1.55 | 3.45 |
| 11 | 1.7 | 1.9 | 2.9 | 3.2 | 2.65 | 3.6 | 2.05 | 1.7 | 1.6 | 1.55 | 1.55 | 3.75 |
| 12 | 2.8 | 1.9 | 3.9 | 3.05 | 2.6 | 3.45 | 2.0 | 1.7 | 1.6 | 1.55 | 1.55 | 2.45 |
| 13 | 2.25 | 2.0 | 3.5 | 2.95 | 2.5 | 3.3 | 2.0 | 1.7 | 1.6 | 1.55 | 1.55 | 2.05 |
| 14 | 2.1 | 3.2 | 3.15 | 2.9 | 2.75 | 3.15 | 2.0 | 1.7 | 1.6 | 1.55 | 1.55 | 1.9 |
| 15 | 2.55 | 3.95 | 2.95 | 2.9 | 2.85 | 3.15 | 2.0 | 1.7 | 1.6 | 1.55 | 1.55 | 1.85 |
| 16 | 6.15 | 3.35 | 2.7 | 2.9 | 2.6 | 3.1 | 1.95 | 1.7 | 1.6 | 1.55 | 1.55 | 1.85 |
| 17 | 3.1 | 2.85 | 2.6 | 2.9 | 2.5 | 2.95 | 1.95 | 1.7 | 1.6 | 1.55 | 1.55 | 1.8 |
| 18 | 5.95 | 3.2 | 2.55 | 2.9 | 2.4 | 2.85 | 1.95 | 1.7 | 1.6 | 1.55 | 1.55 | 1.7 |
| 19 | 5.35 | 3.6 | 2.5 | 2.9 | 2.4 | 2.8 | 1.9 | 1.7 | 1.6 | 1.55 | 1.55 | 1.7 |
| 20 | 3.35 | 3.55 | 2.5 | 2.9 | 2.35 | 2.65 | 1.9 | 1.7 | 1.6 | 1.55 | 1.55 | 1.7 |
| 21 | 3.15 | 4.45 | 3.4 | 2.9 | 2.3 | 2.6 | 1.9 | 1.7 | 1.6 | 1.55 | 1.55 | 1.7 |
| 22 | 3.1 | 3.95 | 4.4 | 2.9 | 2.3 | 2.55 | 1.85 | 1.7 | 1.6 | 1.55 | 1.55 | 1.7 |
| 23 | 3.0 | 3.65 | 4.15 | 3.05 | 2.25 | 2.5 | 1.85 | 1.7 | 1.6 | 1.55 | 1.55 | 1.7 |
| 24 | 2.9 | 3.8 | 5.5 | 3.05 | 2.2 | 2.4 | 1.85 | 1.7 | 1.6 | 1.55 | 1.55 | 1.7 |
| 25 | 2.7 | 3.4 | 6.45 | 3.1 | 2.25 | 2.4 | 1.85 | 1.65 | 1.6 | 1.55 | 1.55 | 2.7 |
| 26 | 2.6 | 3.2 | 6.3 | 3.0 | 6.6 | 2.4 | 1.85 | 1.65 | 1.6 | 1.55 | 1.55 | 4.7 |
| 27 | 2.4 | 3.6 | 5.2 | 2.95 | 6.25 | 2.45 | 1.8 | 1.65 | 1.6 | 1.55 | 1.55 | 4.35 |
| 28 | 2.2 | 3.4 | 4.4 | 2.95 | 5.3 | 2.4 | 1.8 | 1.65 | 1.6 | 1.55 | 1.55 | 3.45 |
| 29 | 2.1 | ..... | 4.0 | 2.9 | 4.5 | 2.35 | 1.8 | 1.65 | 1.6 | 1.55 | 1.55 | 2.9 |
| 30 | 2.0 | ..... | 5.25 | 2.9 | 4.1 | 2.3 | 1.8 | 1.65 | 1.6 | 1.55 | 1.55 | 3.1 |
| 31 | 1.9 | ..... | 7.4 | ..... | 3.7 | ..... | 1.8 | 1.65 | ..... | 1.55 | ..... | 2.85 |

*Rating table for McCloud River near Gregory, Cal., for 1902–1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.50 | 1,340 | 2.40 | 2,042 | 3.30 | 3,090 | 4.40 | 4,990 | 6.20 | 9,120 |
| 1.60 | 1,402 | 2.50 | 2,140 | 3.40 | 3,230 | 4.60 | 5,410 | 6.40 | 9,650 |
| 1.70 | 1,468 | 2.60 | 2,242 | 3.50 | 3,380 | 4.80 | 5,840 | 6.60 | 10,190 |
| 1.80 | 1,538 | 2.70 | 2,349 | 3.60 | 3,535 | 5.00 | 6,280 | 6.80 | 10,740 |
| 1.90 | 1,612 | 2.80 | 2,461 | 3.70 | 3,695 | 5.20 | 6,720 | 7.00 | 11,300 |
| 2.00 | 1,690 | 2.90 | 2,578 | 3.80 | 3,860 | 5.40 | 7,170 | 8.00 | 14,250 |
| 2.10 | 1,772 | 3.00 | 2,700 | 3.90 | 4,030 | 5.60 | 7,630 | | |
| 2.20 | 1,858 | 3.10 | 2,825 | 4.00 | 4,210 | 5.80 | 8,110 | | |
| 2.30 | 1,948 | 3.20 | 2,955 | 4.20 | 4,585 | 6.00 | 8,600 | | |

NOTE.—This table is based on discharge measurements made during 1902–1906 and is well defined.

*Monthly discharge of McCloud River near Gregory, Cal., for 1906.*

[Drainage area, 608 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 8,990 | 1,370 | 2,540 | 156,000 | 4.18 | 4.82 |
| February | 5,100 | 1,500 | 2,600 | 144,000 | 4.28 | 4.46 |
| March | 12,400 | 2,140 | 4,160 | 256,000 | 6.84 | 7.89 |
| April | 7,630 | 2,580 | 3,110 | 185,000 | 5.12 | 5.71 |
| May | 10,200 | 1,860 | 3,070 | 189,000 | 5.05 | 5.82 |
| June | 9,920 | 1,950 | 3,480 | 207,000 | 5.72 | 6.38 |
| July | 1,950 | 1,540 | 1,690 | 104,000 | 2.78 | 3.20 |
| August | 1,540 | 1,440 | 1,480 | 91,000 | 2.43 | 2.80 |
| September | 1,400 | 1,400 | 1,400 | 83,300 | 2.30 | 2.57 |
| October | 1,400 | 1,370 | 1,380 | 84,800 | 2.27 | 2.62 |
| November | 2,000 | 1,370 | 1,400 | 83,300 | 2.30 | 2.57 |
| December | 5,620 | 1,340 | 2,070 | 127,000 | 3.40 | 3.92 |
| The year | 12,400 | 1,340 | 2,360 | 1,710,000 | 3.89 | 52.76 |

NOTE.—These values are excellent.

## STONY CREEK DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Stony Creek drains a portion of the Coast Range. It flows in a northerly direction and discharges its waters into the Sacramento River near Orland, Cal. It has numerous tributaries, all of which are torrential in their character. The formation on the higher elevations is of granite, with good soil covering, and is heavily timbered. In the lower portion of the drainage basin the formation is shale, sandstone, and conglomerate, with heavy growth of brush and grass. This portion of the basin is used extensively for pasturage. The soil being heavy, it packs readily, causing a large per cent of run-off. The mean average rainfall on the higher elevation is about 40 inches, while on the lower reaches it is 20 inches. The precipitation is almost wholly in the form of rain, with some snow on the upper reaches, which soon melts and only adds to the flood discharge.

The gaging station on this stream is located near the point where it emerges from the foothills and enters the Sacramento Valley.

## STONY CREEK NEAR FRUTO, CAL.

This station was established on January 30, 1901. It is located at Julian's ranch, 7 miles northwest of Fruto, and $1\frac{3}{4}$ miles above the proposed mill-site dam. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 153, where are given also references to publications that contain data for previous years.

*Discharge measurements of Stony Creek near Fruto, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 8 [a] | R. S. Hawley | 137 | 216 | 5.70 | 476 |
| February 24 | F. R. S. Buttemer | 151 | 455 | 7.10 | 2,280 |
| March 8 | do | 146 | 412 | 6.40 | 1,680 |
| March 16 | do | 140 | 336 | 6.00 | 1,280 |
| March 16 | do | 140 | 336 | 6.00 | 1,280 |
| May 2 | R. S. Hawley | 136 | 271 | 5.52 | 789 |
| May 18 | do | 132 | 222 | 5.02 | 497 |
| June 13 | do | 132 | 218 | 5.03 | 491 |
| September 20 [b] | S. G. Bennett | 27 | 24 | 3.65 | 18 |
| October 5 [b] | R. S. Hawley | 22 | 17.6 | 3.62 | 18.1 |
| October 14 [b] | S. G. Bennett | 26 | 25 | 3.65 | 17.6 |

[a] During the high water of January 18, 1906, the channel at the cable was raised by a deposit of gravel, which was gradually removed during the two or three months following. These measurements were made before the channel had assumed its normal condition.

[b] Measurement made by wading at section below the gage.

*Daily gage height, in feet, of Stony Creek near Fruto, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.0 | 5.8 | 6.75 | 7.85 | 5.4 | 5.3 | 4.5 | 3.8 | 3.6 | 3.7 | 3.7 | 3.8 |
| 2 | 4.0 | 5.8 | 6.55 | 7.4 | 5.4 | 5.3 | 4.5 | 3.8 | 3.6 | 3.7 | 3.7 | 3.8 |
| 3 | 4.0 | 5.8 | 9.35 | 7.05 | 5.3 | 5.3 | 4.4 | 3.8 | 3.6 | 3.7 | 3.8 | 3.8 |
| 4 | 4.0 | 5.8 | 7.25 | 6.75 | 5.3 | 5.4 | 4.4 | 3.8 | 3.6 | 3.7 | 3.8 | 3.8 |
| 5 | 4.0 | 5.8 | 6.7 | 6.55 | 5.3 | 5.3 | 4.3 | 3.8 | 3.6 | 3.7 | 3.9 | 3.8 |
| 6 | 4.0 | 5.7 | 6.5 | 6.4 | 5.2 | 5.3 | 4.3 | 3.8 | 3.6 | 3.7 | 3.9 | 3.8 |
| 7 | 4.0 | 5.7 | 6.5 | 6.3 | 5.2 | 5.3 | 4.2 | 3.8 | 3.6 | 3.7 | 3.9 | 4.2 |
| 8 | 4.0 | 5.7 | 6.4 | 6.2 | 5.2 | 5.2 | 4.2 | 3.8 | 3.6 | 3.7 | 3.9 | 4.2 |
| 9 | 4.0 | 5.7 | 6.4 | 6.1 | 5.2 | 5.2 | 4.2 | 3.8 | 3.6 | 3.7 | 3.9 | 4.3 |
| 10 | 4.0 | 5.8 | 6.3 | 6.1 | 5.2 | 5.1 | 4.2 | 3.8 | 3.6 | 3.7 | 3.9 | 5.6 |
| 11 | 4.0 | 6.0 | 6.95 | 6.0 | 5.1 | 5.1 | 4.2 | 3.8 | 3.6 | 3.7 | 3.9 | 5.6 |
| 12 | 6.2 | 6.1 | 6.65 | 6.0 | 5.1 | 5.0 | 4.1 | 3.7 | 3.6 | 3.7 | 3.9 | 5.6 |
| 13 | 6.65 | 6.0 | 6.45 | 6.0 | 5.1 | 5.0 | 4.1 | 3.7 | 3.6 | 3.7 | 3.9 | 4.8 |
| 14 | 7.25 | 7.85 | 6.25 | 5.9 | 5.1 | 5.0 | 4.1 | 3.7 | 3.6 | 3.7 | 3.9 | 4.7 |
| 15 | 8.0 | 7.35 | 6.05 | 5.9 | 5.1 | 5.0 | 4.1 | 3.7 | 3.6 | 3.7 | 3.9 | 4.6 |
| 16 | 12.5 | 6.9 | 6.0 | 5.8 | 5.1 | 5.1 | 4.1 | 3.7 | 3.6 | 3.7 | 3.9 | 4.5 |
| 17 | 7.6 | 7.25 | 6.0 | 5.7 | 5.0 | 5.0 | 4.1 | 3.7 | 3.6 | 3.7 | 3.9 | 4.5 |
| 18 | 14.5 | 7.05 | 5.9 | 5.6 | 5.0 | 5.0 | 4.1 | 3.7 | 3.6 | 3.7 | 3.9 | 4.4 |
| 19 | 11.0 | 8.0 | 5.8 | 5.6 | 5.0 | 5.0 | 4.1 | 3.7 | 3.6 | 3.7 | 3.9 | 4.4 |
| 20 | 8.65 | 7.5 | 5.8 | 5.5 | 5.0 | 4.9 | 4.1 | 3.7 | 3.6 | 3.7 | 3.9 | 4.3 |
| 21 | 7.65 | 7.45 | 6.9 | 5.5 | 5.0 | 4.9 | 4.1 | 3.7 | 3.6 | 3.7 | 3.9 | 4.3 |
| 22 | 7.1 | 7.25 | 6.65 | 5.4 | 5.0 | 4.9 | 4.0 | 3.7 | 3.6 | 3.7 | 3.9 | 4.2 |
| 23 | 6.75 | 7.15 | 8.0 | 5.5 | 5.0 | 4.8 | 4.0 | 3.7 | 3.7 | 3.7 | 3.9 | 4.2 |
| 24 | 6.55 | 7.1 | 7.6 | 5.5 | 5.1 | 4.8 | 4.0 | 3.7 | 3.7 | 3.7 | 3.9 | 4.2 |
| 25 | 6.35 | 7.0 | 8.25 | 5.5 | 5.2 | 4.8 | 3.9 | 3.7 | 3.7 | 3.7 | 3.8 | 4.2 |
| 26 | 6.25 | 6.8 | 7.65 | 5.4 | 5.3 | 4.8 | 3.9 | 3.6 | 3.7 | 3.7 | 3.8 | 9.0 |
| 27 | 6.1 | 7.15 | 7.45 | 5.4 | 5.5 | 4.8 | 3.9 | 3.6 | 3.7 | 3.7 | 3.8 | 7.8 |
| 28 | 6.1 | 7.05 | 7.25 | 5.5 | 5.95 | 4.8 | 3.9 | 3.6 | 3.7 | 3.7 | 3.8 | 6.3 |
| 29 | 6.0 | ..... | 7.05 | 5.5 | 5.65 | 4.7 | 3.8 | 3.6 | 3.7 | 3.7 | 3.8 | 5.65 |
| 30 | 5.9 | ..... | 11.0 | 5.5 | 5.5 | 4.6 | 3.8 | 3.6 | 3.7 | 3.7 | 3.8 | 5.2 |
| 31 | 5.8 | ..... | 8.35 | ..... | 5.4 | ..... | 3.8 | 3.6 | ..... | 3.7 | ..... | 4.9 |

*Rating table for Stony Creek near Fruto, Cal., from March 8, 1906, to December 31, 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.60 | 13 | 4.40 | 213 | 5.20 | 580 | 6.00 | 1,250 | 7.60 | 3,150 |
| 3.70 | 29 | 4.50 | 250 | 5.30 | 640 | 6.20 | 1,460 | 7.80 | 3,410 |
| 3.80 | 48 | 4.60 | 290 | 5.40 | 705 | 6.40 | 1,680 | 8.00 | 3,690 |
| 3.90 | 70 | 4.70 | 335 | 5.50 | 780 | 6.60 | 1,905 | 9.00 | 5,270 |
| 4.00 | 93 | 4.80 | 380 | 5.60 | 865 | 6.80 | 2,140 | 10.00 | 7,280 |
| 4.10 | 119 | 4.90 | 430 | 5.70 | 955 | 7.00 | 2,390 | 11.00 | 10,200 |
| 4.20 | 149 | 5.00 | 480 | 5.80 | 1,050 | 7.20 | 2,640 | | |
| 4.30 | 179 | 5.10 | 530 | 5.90 | 1,150 | 7.36 | 2,890 | | |

NOTE.—This table is based on 9 discharge measurements made during 1906 and 3 during 1904, and is well defined below gage height 6.4 feet.

*Monthly discharge of Stony Creek near Fruto, Cal., for 1906.*

[Drainage area, 760 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 22,200 | 150 | 2,230 | 137,000 | 2.93 | 3.38 |
| February | 3,320 | 480 | 1,540 | 85,500 | 2.03 | 2.11 |
| March | 10,200 | 1,050 | 2,500 | 154,000 | 3.29 | 3.79 |
| April | 3,480 | 705 | 1,280 | 76,200 | 1.68 | 1.87 |
| May | 1,200 | 480 | 610 | 37,500 | .803 | .93 |
| June | 705 | 290 | 495 | 29,500 | .651 | .73 |
| July | 250 | 48 | 127 | 7,800 | .167 | .19 |
| August | 48 | 13 | 32.6 | 2,000 | .043 | .05 |
| September | 29 | 13 | 17.3 | 1,030 | .023 | .03 |
| October | 29 | 29 | 29.0 | 1,780 | .038 | .04 |
| November | 70 | 29 | 61.4 | 3,650 | .081 | .09 |
| December | 5,270 | 48 | 582 | 35,800 | .766 | .88 |
| The year | 22,200 | 13 | 792 | 572,000 | 1.04 | 14.10 |

NOTE.—Discharges were obtained from the 1905 table, January 1 to 15, and by the indirect method for shifting channels, January 16 to March 7. Values are rated as follows: March to July and December, good; remainder of 1906, fair.

## MISCELLANEOUS MEASUREMENTS IN STONY CREEK DRAINAGE BASIN.

The following miscellaneous measurements were made of Stony Creek just above its junction with Little Stony Creek:

September 18: Width, 26 feet; area, 38 square feet; discharge, 26 second-feet.
October 13: Width, 26 feet; area, 34 square feet; discharge, 21 second-feet.

## CACHE CREEK DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Cache Creek drains that portion of the eastern slope of the Coast Range directly north from the Puta Creek basin. This basin is long and narrow, extending from northwest to southeast; it has numerous tributaries, of which North Fork is the largest. Most of these tributaries are torrential in their character, but the flow of the main stream is regulated largely by its discharge from Clear Lake, which is fed by numerous creeks having their source in the higher portion of the drainage basin. The lake covers an area of 65 square miles, and

has a drainage area of 417 square miles. The streams that enter Cache Creek below Clear Lake are practically dry during the summer months. There are large cultivated areas on the west side of Clear Lake, a greater portion of which is meadow land used for stock raising. There are two gaging stations located on this stream—one at Lower Lake directly at the point where the stream discharges from the lake and one at Yolo a short distance below where it emerges from the foothills. There are numerous diversions above the gaging station at Yolo which take practically the entire flow during the summer months. This water is used for irrigation in the vicinity of Woodland and Yolo, where the soil is rich and deep and susceptible of the highest state of cultivation.

### CACHE CREEK AT LOWER LAKE, CAL.

This station was established January 1, 1900. It is located three-fourths mile from Lower Lake, Cal. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 169, where are given also references to publications that contain data for previous years. The following measurement was made March 7, 1906:

Width, 64 feet; area, 301 square feet; gage height, 6.80 feet; discharge, 999 second-feet.

*Daily gage height, in feet, of Cache Creek at Lower Lake, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.5 | 5.35 | 6.35 | 8.9 | 7.0 | 5.85 | 5.1 | 4.35 | 3.65 | 3.2 | 2.9 | 2.7 |
| 2 | 2.5 | 5.3 | 6.25 | 8.9 | 6.9 | 5.85 | 5.1 | 4.3 | 3.6 | 3.25 | 2.85 | 2.75 |
| 3 | 2.5 | 5.3 | 7.2 | 8.95 | 6.9 | 5.8 | 5.05 | 4.3 | 3.6 | 3.25 | 2.85 | 2.75 |
| 4 | 2.5 | 5.3 | 6.75 | 8.9 | 6.8 | 5.8 | 5.05 | 4.3 | 3.6 | 3.2 | 2.85 | 2.75 |
| 5 | 2.5 | 5.3 | 6.8 | 8.9 | 6.75 | 5.75 | 5.0 | 4.25 | 3.6 | 3.2 | 2.85 | 2.7 |
| 6 | 2.5 | 5.3 | 6.8 | 8.85 | 6.65 | 5.75 | 5.0 | 4.25 | 3.55 | 3.15 | 2.9 | 2.7 |
| 7 | 2.45 | 5.25 | 6.8 | 8.85 | 6.6 | 5.7 | 4.95 | 4.25 | 3.55 | 3.15 | 2.9 | 2.7 |
| 8 | 2.5 | 5.25 | 6.8 | 8.8 | 6.55 | 5.7 | 4.95 | 4.25 | 3.55 | 3.15 | 2.9 | 2.7 |
| 9 | 2.45 | 5.25 | 6.8 | 8.8 | 6.5 | 5.65 | 4.9 | 4.2 | 3.55 | 3.15 | 2.9 | 2.8 |
| 10 | 2.5 | 5.25 | 6.8 | 8.75 | 6.45 | 5.6 | 4.85 | 4.2 | 3.4 | 3.15 | 2.9 | 3.15 |
| 11 | 2.5 | 5.25 | 6.8 | 8.55 | 6.5 | 5.6 | 4.85 | 4.15 | 3.4 | 3.2 | 2.9 | 3.35 |
| 12 | 2.75 | 5.2 | 7.1 | 8.45 | 6.35 | 5.55 | 4.8 | 4.15 | 3.45 | 3.2 | 2.95 | 3.3 |
| 13 | 2.9 | 5.2 | 7.1 | 8.35 | 6.35 | 5.5 | 4.8 | 4.1 | 3.5 | 3.15 | 2.95 | 3.3 |
| 14 | 3.05 | 6.1 | 7.3 | 8.3 | 6.5 | 5.5 | 4.8 | 4.1 | 3.45 | 3.1 | 2.95 | 3.3 |
| 15 | 3.2 | 5.4 | 7.0 | 8.4 | 6.35 | 5.45 | 4.75 | 4.05 | 3.4 | 3.1 | 2.95 | 3.35 |
| 16 | 4.75 | 5.4 | 7.0 | 8.2 | 6.3 | 5.45 | 4.7 | 4.0 | 3.35 | 3.15 | 2.9 | 3.4 |
| 17 | 4.0 | 5.4 | 7.0 | 8.0 | 6.25 | 5.5 | 4.7 | 3.95 | 3.35 | 3.1 | 3.0 | 3.4 |
| 18 | 5.18 | 5.5 | 6.9 | 7.9 | 6.2 | 5.4 | 4.65 | 3.95 | 3.35 | 3.1 | 2.9 | 3.4 |
| 19 | 5.2 | 5.6 | 6.8 | 7.75 | 6.15 | 5.4 | 4.65 | 3.9 | 3.3 | 3.0 | 2.85 | 3.4 |
| 20 | 5.3 | 5.9 | 7.2 | 7.65 | 6.1 | 5.45 | 4.6 | 3.85 | 3.3 | 3.0 | 2.85 | 3.4 |
| 21 | 5.3 | 5.8 | 7.3 | 7.6 | 6.05 | 5.4 | 4.6 | 3.85 | 3.3 | 2.95 | 2.95 | 3.4 |
| 22 | 5.4 | 5.9 | 7.2 | 7.4 | 6.0 | 5.35 | 4.55 | 3.85 | 3.25 | 2.9 | 2.8 | 3.4 |
| 23 | 5.4 | 6.1 | 7.5 | 7.4 | 5.9 | 5.3 | 4.55 | 3.8 | 3.35 | 2.9 | 2.8 | 3.35 |
| 24 | 5.4 | 6.2 | 7.6 | 7.35 | 5.85 | 5.3 | 4.4 | 3.8 | 3.35 | 2.9 | 2.85 | 3.35 |
| 25 | 5.45 | 6.2 | 7.75 | 7.3 | 5.9 | 5.25 | 4.5 | 3.8 | 3.25 | 2.9 | 2.85 | 3.4 |
| 26 | 5.4 | 6.2 | 8.05 | 7.25 | 5.95 | 5.25 | 4.45 | 3.75 | 3.25 | 2.9 | 2.8 | 3.75 |
| 27 | 5.4 | 6.4 | 8.1 | 7.5 | 6.0 | 5.25 | 4.45 | 3.75 | 3.25 | 2.9 | 2.75 | 3.7 |
| 28 | 5.4 | 6.5 | 8.1 | 7.2 | 5.95 | 5.2 | 4.4 | 3.7 | 3.25 | 2.9 | 2.75 | 3.75 |
| 29 | 5.4 | ..... | 8.1 | 7.1 | 5.95 | 5.15 | 4.4 | 3.7 | 3.2 | 2.9 | 2.8 | 3.8 |
| 30 | 5.4 | ..... | 8.8 | 7.0 | 5.9 | 5.1 | 4.4 | 3.7 | 3.2 | 2.9 | 2.75 | 3.9 |
| 31 | 5.35 | ..... | 9.3 | ..... | 5.9 | ..... | 4.35 | 3.65 | ..... | 2.9 | ..... | 4.0 |

*Rating table for Cache Creek at Lower Lake, Cal., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.40 | 27 | 3.30 | 135 | 4.20 | 296 | 5.20 | 552 | 7.00 | 1,120 |
| 2.50 | 37 | 3.40 | 149 | 4.30 | 318 | 5.40 | 610 | 7.20 | 1,188 |
| 2.60 | 48 | 3.50 | 163 | 4.40 | 341 | 5.60 | 670 | 7.40 | 1,256 |
| 2.70 | 59 | 3.60 | 178 | 4.50 | 365 | 5.80 | 732 | 7.60 | 1,324 |
| 2.80 | 71 | 3.70 | 194 | 4.60 | 390 | 6.00 | 795 | 7.80 | 1,392 |
| 2.90 | 83 | 3.80 | 212 | 4.70 | 416 | 6.20 | 859 | 8.00 | 1,460 |
| 3.00 | 95 | 3.90 | 232 | 4.80 | 442 | 6.40 | 923 | 9.00 | 1,840 |
| 3.10 | 108 | 4.00 | 252 | 4.90 | 469 | 6.60 | 988 | | |
| 3.20 | 121 | 4.10 | 274 | 5.00 | 496 | 6.80 | 1,054 | | |

NOTE.—This table is based on discharge measurements made during 1904–6 and is well defined below gage height 7 feet.

*Monthly discharge of Cache Creek at Lower Lake, Cal., for 1906.*

[Drainage area, 500 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 625 | 32 | 316 | 19,400 | 0.632 | 0.73 |
| February | 955 | 552 | 675 | 37,500 | 1.35 | 1.41 |
| March | 1,960 | 875 | 1,220 | 75,000 | 2.44 | 2.81 |
| April | 1,820 | 1,120 | 1,510 | 89,800 | 3.02 | 3.37 |
| May | 1,120 | 748 | 894 | 55,000 | 1.79 | 2.06 |
| June | 748 | 524 | 639 | 38,000 | 1.28 | 1.43 |
| July | 524 | 330 | 423 | 26,000 | .846 | .98 |
| August | 330 | 186 | 256 | 15,700 | .512 | .59 |
| September | 186 | 121 | 150 | 8,930 | .300 | .33 |
| October | 128 | 83 | 103 | 6,330 | .206 | .24 |
| November | 95 | 65 | 79.4 | 4,720 | .159 | .18 |
| December | 252 | 59 | 133 | 8,180 | .266 | .31 |
| The year | 1,960 | 32 | 533 | 385,000 | 1.07 | 14.44 |

NOTE.—These values are excellent.

## CACHE CREEK NEAR YOLO, CAL.

This station was established January 1, 1903. It is located at the wagon bridge on the road from Woodland to Yolo, about 1,000 feet above the Southern Pacific Railroad bridge. A new wagon bridge, which greatly improves the channel conditions, was erected during 1904. The station was reestablished on the new bridge December 4, 1904. Numerous diversions are made from Cache Creek above this station which take practically all of the summer flow. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 172, where are given also references to publications that contain data for previous years.

*Discharge measurements of Cache Creek near Yolo, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 5 | F. R. S. Buttemer | 93 | 262 | 3.88 | 850 |
| February 16 | do | 97 | 445 | 5.15 | 1,660 |
| February 20 | do | 97 | 479 | 5.79 | 2,090 |
| March 5 | do | 102 | 578 | 6.60 | 2,580 |
| March 13 | do | 102 | 592 | 6.85 | 2,540 |
| April 13 | R. S. Hawley | 99 | 482 | 6.05 | 2,090 |
| April 24 | W. C. Sawyer | 97 | 428 | 5.36 | 1,810 |
| May 1 | do | 96 | 380 | 4.95 | 1,520 |
| May 6 | do | 83 | 127 | 2.25 | 254 |
| May 7 | do | 133 | 2,180 | 19.95 | 11,800 |
| May 7 | do | 133 | 2,150 | 19.72 | 10,900 |
| May 7 | do | 133 | 2,230 | 20.40 | 12,100 |
| May 7 | do | 133 | 2,240 | 20.43 | 11,300 |
| May 7 | do | 133 | 2,270 | 20.65 | 12,000 |
| May 8 | do | 98 | 400 | 4.99 | 1,540 |
| May 15 | do | 96 | 338 | 4.49 | 1,240 |
| July 13 | R. S. Hawley | 92 | 160 | 2.50 | 321 |
| July 30 | do | 91 | 137 | 2.10 | 224 |
| October 4 | do | 10 | 28 | 1.00 | 3.3 |

NOTE.—A landslide occurred in Cache Creek canyon, above the station, on May 2, damming the flow. This dam was overtopped on May 7, when the creek rose to a maximum gage height of 20.8 feet. The measurements of this date were made at the crest of the flood.

*Daily gage height, in feet, of Cache Creek near Yolo, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 4.05 | 5.5 | 10.0 | 5.0 | 4.3 | 3.1 | 2.15 | 1.65 | 1.1 | 0.85 | ..... |
| 2 | ..... | 4.0 | 5.2 | 8.6 | 4.55 | 4.2 | 3.1 | 2.1 | 1.65 | 1.1 | .85 | ..... |
| 3 | ..... | 3.95 | 5.55 | 8.0 | 2.95 | 4.15 | 3.05 | 2.0 | 1.6 | 1.95 | .85 | ..... |
| 4 | ..... | 3.95 | 8.5 | 7.6 | 2.6 | 4.1 | 3.0 | 2.0 | 1.6 | 1.9 | .8 | ..... |
| 5 | ..... | 3.9 | 6.7 | 7.3 | 2.25 | 4.1 | 3.0 | 2.0 | 1.6 | 1.05 | .8 | ..... |
| 6 | ..... | 3.85 | 6.15 | 7.0 | 2.2 | 4.05 | 2.8 | 1.95 | 1.6 | 1.0 | .8 | ..... |
| 7 | ..... | 3.85 | 5.85 | 6.8 | 12.1 | 4.0 | 2.65 | 1.95 | 1.5 | 1.0 | .8 | ..... |
| 8 | ..... | 3.8 | 5.6 | 6.7 | 5.1 | 3.95 | 2.6 | 1.95 | 1.5 | 1.0 | .8 | ..... |
| 9 | ..... | 3.75 | 5.5 | 6.6 | 4.7 | 3.9 | 2.6 | 1.95 | 1.5 | 1.0 | .8 | ..... |
| 10 | ..... | 3.75 | 5.4 | 6.4 | 4.6 | 3.85 | 2.6 | 2.0 | 1.5 | 1.0 | .8 | ..... |
| 11 | ..... | 3.7 | 5.3 | 6.35 | 4.6 | 3.8 | 2.5 | 2.0 | 1.5 | 1.0 | .8 | 5.75 |
| 12 | ..... | 3.7 | 9.3 | 6.3 | 4.55 | 3.8 | 2.5 | 2.0 | 1.5 | 1.0 | .75 | 3.3 |
| 13 | 4.35 | 3.7 | 7.25 | 6.1 | 4.6 | 3.8 | 2.5 | 2.0 | 1.45 | 1.0 | .75 | 2.7 |
| 14 | 6.3 | 3.7 | 6.45 | 6.0 | 4.5 | 3.75 | 2.5 | 2.0 | 1.45 | .95 | .75 | 2.5 |
| 15 | 4.45 | 6.85 | 6.0 | 5.9 | 4.45 | 3.7 | 2.45 | 2.0 | 1.45 | .95 | .75 | 2.45 |
| 16 | 9.9 | 5.2 | 5.8 | 5.8 | 4.4 | 3.65 | 2.45 | 2.0 | 1.45 | .95 | .7 | 2.45 |
| 17 | 14.0 | 4.7 | 5.6 | 5.7 | 4.35 | 3.65 | 2.45 | 1.95 | 1.45 | .9 | ..... | 2.45 |
| 18 | 14.05 | 5.45 | 5.5 | 5.75 | 4.3 | 3.65 | 2.4 | 1.95 | 1.45 | .9 | ..... | 2.4 |
| 19 | 25.7 | 6.65 | 5.4 | 5.65 | 4.3 | 3.6 | 2.35 | 1.95 | 1.45 | .9 | ..... | 2.4 |
| 20 | 10.25 | 5.8 | 5.3 | 5.55 | 4.25 | 3.5 | 2.3 | 1.8 | 1.35 | .9 | ..... | 2.4 |
| 21 | 6.75 | 7.8 | 7.25 | 5.45 | 4.2 | 3.4 | 2.3 | 1.7 | 1.3 | .9 | ..... | 2.4 |
| 22 | 5.8 | 7.25 | 7.0 | 5.4 | 4.15 | 3.4 | 2.3 | 1.7 | 1.3 | .9 | ..... | 2.4 |
| 23 | 5.35 | 6.4 | 6.7 | 5.4 | 4.1 | 3.35 | 2.35 | 1.65 | 1.3 | .9 | ..... | 2.4 |
| 24 | 5.05 | 8.3 | 10.7 | 5.3 | 4.05 | 3.3 | 2.3 | 1.7 | 1.25 | .9 | ..... | 2.4 |
| 25 | 4.8 | 7.45 | 9.95 | 5.25 | 4.2 | 3.25 | 2.3 | 1.75 | 1.25 | .85 | ..... | 2.4 |
| 26 | 5.6 | 6.0 | 11.0 | 5.2 | 4.55 | 3.2 | 2.25 | 1.75 | 1.2 | .85 | ..... | 4.2 |
| 27 | 4.4 | 5.65 | 9.25 | 5.15 | 4.7 | 3.2 | 2.2 | 1.7 | 1.15 | .85 | ..... | 7.55 |
| 28 | 4.3 | 5.8 | 7.95 | 5.3 | 4.85 | 3.2 | 2.2 | 1.7 | 1.15 | .85 | ..... | 3.95 |
| 29 | 4.2 | ..... | 7.3 | 5.2 | 4.7 | 3.2 | 2.2 | 1.65 | 1.1 | .85 | ..... | 3.3 |
| 30 | 4.15 | ..... | 9.65 | 5.1 | 4.45 | 3.15 | 2.15 | 1.65 | 1.1 | .85 | ..... | 3.1 |
| 31 | 4.1 | ..... | 15.85 | ..... | 4.35 | ..... | 2.15 | 1.65 | ..... | .85 | ..... | 2.8 |

NOTE.—The creek was dry January 1 to 12 and November 17 to December 10. The gage height for May 7 is the mean of a large number of readings at short intervals.

*Rating table for Cache Creek near Yolo, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.90 | 0 | 1.80 | 145 | 2.60 | 358 | 3.40 | 650 | 4.40 | 1,168 |
| 1.00 | 3 | 1.90 | 169 | 2.70 | 388 | 3.50 | 692 | 4.60 | 1,284 |
| 1.10 | 17 | 2.00 | 193 | 2.80 | 420 | 3.60 | 737 | 4.80 | 1,405 |
| 1.20 | 32 | 2.10 | 217 | 2.90 | 455 | 3.70 | 785 | 5.00 | 1,537 |
| 1.30 | 48 | 2.20 | 243 | 3.00 | 491 | 3.80 | 835 | 5.20 | 1,671 |
| 1.40 | 65 | 2.30 | 271 | 3.10 | 530 | 3.90 | 887 | 5.40 | 1,805 |
| 1.50 | 85 | 2.40 | 299 | 3.20 | 570 | 4.00 | 941 | 5.60 | 1,939 |
| 1.60 | 105 | 2.50 | 328 | 3.30 | 610 | 4.20 | 1,053 | 5.80 | 2,073 |
| 1.70 | 125 | | | | | | | | |

NOTE.—This table is based on discharge measurements made during 1906 and is well defined between gage heights 1 foot and 7 feet. Above gage height 5 feet the rating curve is a tangent, the difference being 67 per tenth.

*Monthly discharge of Cache Creek near Yolo, Cal., for 1906.*

[Drainage area, 1,280 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 15,400 | 0 | 2,000 | 123,000 | 1.56 | 1.80 |
| February | 3,750 | 785 | 1,660 | 92,200 | 1.30 | 1.35 |
| March | 8,810 | 1,670 | 3,040 | 187,000 | 2.38 | 2.74 |
| April | 4,890 | 1,600 | 2,360 | 140,000 | 1.84 | 2.05 |
| May | 6,290 | 243 | 1,270 | 78,100 | .992 | 1.14 |
| June | 1,110 | 550 | 784 | 46,700 | .613 | .68 |
| July | 530 | 229 | 333 | 20,500 | .260 | .30 |
| August | 229 | 115 | 166 | 10,200 | .130 | .15 |
| September | 115 | 17 | 69.4 | 4,130 | .054 | .06 |
| October | 181 | 0 | 13.6 | 836 | .011 | .01 |
| November | 0 | 0 | 0 | 0 | .00 | 1.00 |
| December | 3,250 | 0 | 435 | 26,700 | .340 | .39 |
| The year | 15,400 | 0 | 1,010 | 729,000 | .790 | 10.67 |

NOTE.—Values are rated as follows: January and September, good; October, fair; remainder of 1906, excellent.

## PUTA CREEK DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Puta Creek drains a portion of the eastern slope of the Coast Range, its waters discharging into Sacramento River, through what is known as the Yolo basin, in the vicinity of Davis, Cal. This basin is rather long and narrow, extending from west to east; it has numerous tributaries which have a heavy flood discharge during the winter months, but are practically dry during the summer. This stream is torrential in its flow. It has a comparatively small drainage basin with an exceptionally heavy rainfall, especially on the higher elevations in the vicinity of Mount St. Helena. A five-year rainfall record at Helen Mine, on the northern slope of Mount St. Helena, gives an average of 99.52 inches. The precipitation is less at lower elevations. The upper reaches of the basin are well timbered, but the lower part is comparatively barren of timber, though it has a considerable growth of brush extending to a point where the stream leaves the foothills.

The areas in the lower portion of the basin are used principally for pasturage. The topography of the country is rough and precipitous. The underlying rock is an impervious slate and serpentine, with a thin soil covering. There is comparatively little tilled land in the basin above where the stream emerges from the foothills at Winters. Below this point the soil is deep and susceptible to high cultivation, and at present is used for raising grain and fruit.

### PUTA CREEK NEAR GUENOC, CAL.

This station was established February 12, 1904. It is located about 2 miles below the old town of Guenoc, near the Asbill ranch house and at the Guenoc dam site. The nearest post-office is at Middletown, Cal. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 180, where are given also references to publications that contain data for previous years.

*Discharge measurements of Puta Creek near Guenoc, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 15[a] | S. Asbill | 145 | 1,300 | 10.55 | 8,250 |
| January 16[a] | do | 152 | 1,860 | 14.25 | 12,500 |
| January 23 | do | 126 | 970 | 8.60 | 3,540 |
| January 23 | do | 124 | 868 | 8.00 | 2,930 |
| January 24 | do | 124 | 830 | 7.80 | 3,280 |
| January 24 | do | 125 | 815 | 7.90 | 3,070 |
| February 15 | do | 94 | 202 | 6.25 | 830 |
| February 15 | do | 94 | 229 | 6.35 | 943 |
| March 6 | R. S. Hawley | 93 | 153 | 5.59 | 479 |
| March 7 | do | 93 | 136 | 5.50 | 405 |
| March 19 | do | 82 | 167 | 5.48 | 379 |
| March 20 | do | 114 | 480 | 7.00 | 1,950 |
| March 21 | do | 104 | 320 | 6.52 | 1,230 |
| April 17 | do | 82 | 78 | 5.00 | 175 |
| April 18 | do | 82 | 78 | 4.99 | 168 |
| May 7 | do | [b] 32 | [a] 39 | 4.84 | 118 |
| May 8 | do | [b] 32 | [b] 37 | 4.82 | 108 |
| July 27 | do | [b] 20 | [b] 13.2 | 4.29 | 18.2 |
| July 28 | do | [b] 20 | [b] 13.2 | 4.28 | 18.1 |

[a] Measured by floats. [b] Wading section.

*Daily gage height, in feet, of Puta Creek, near Guenoc, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. |
|---|---|---|---|---|---|---|---|
| 1 | 3.7 | 4.9 | 5.5 | 6.3 | 4.9 | 5.0 | 4.6 |
| 2 | 3.7 | 4.9 | 6.0 | 6.1 | 4.9 | 5.2 | 4.6 |
| 3 | 3.7 | 4.9 | 6.65 | 6.0 | 4.9 | 5.9 | 4.6 |
| 4 | 3.7 | 4.9 | 6.35 | 5.8 | 4.8 | 5.4 | 4.6 |
| 5 | 3.7 | 4.8 | 5.8 | 5.7 | 4.8 | 5.1 | 4.5 |
| 6 | 3.7 | 4.8 | 5.4 | 5.6 | 4.8 | 5.1 | 4.5 |
| 7 | 3.7 | 5.0 | 5.4 | 5.6 | 4.8 | 5.0 | 4.5 |
| 8 | 3.7 | 4.9 | 5.3 | 5.6 | 4.8 | 5.0 | 4.4 |
| 9 | 3.7 | 4.9 | 5.3 | 5.5 | 4.8 | 5.0 | 4.4 |
| 10 | 3.7 | 4.8 | 5.3 | 5.5 | 4.8 | 5.0 | 4.4 |
| 11 | 4.0 | 7.0 | 5.3 | 5.4 | 4.8 | 5.5 | 4.4 |
| 12 | 8.5 | 6.9 | 5.2 | 5.4 | 4.8 | 5.3 | ..... |
| 13 | 9.2 | 6.45 | 5.4 | 5.4 | 4.8 | 5.2 | ..... |
| 14 | 10.5 | 6.35 | 5.6 | 5.3 | 4.8 | 5.1 | ..... |
| 15 | 10.0 | 5.55 | 5.5 | 5.2 | 4.8 | 5.0 | 4.3 |

*Daily gage height, in feet, of Puta Creek, near Guenoc, Cal., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. |
|---|---|---|---|---|---|---|---|
| 16 | 11.05 | 5.4 | 5.4 | 5.1 | 4.8 | 5.0 | 4.3 |
| 17 | 9.55 | 5.7 | 5.4 | 5.0 | 4.8 | 4.9 | 4.3 |
| 18 | 13.25 | 6.2 | 5.5 | 4.9 | ..... | 4.9 | 4.3 |
| 19 | 8.25 | 6.5 | 5.5 | 4.9 | 4.8 | 4.8 | 4.3 |
| 20 | 6.15 | 6.6 | 6.4 | 4.9 | 4.8 | 4.8 | 4.3 |
| 21 | 5.7 | 6.45 | 6.35 | 4.8 | 4.8 | 4.8 | 4.3 |
| 22 | 5.6 | 6.6 | 6.35 | 4.9 | 4.8 | ..... | 4.3 |
| 23 | 5.45 | 7.15 | 7.4 | 5.1 | 4.8 | 4.7 | 4.3 |
| 24 | 5.35 | 7.4 | 8.1 | 5.1 | 4.8 | 4.7 | 4.3 |
| 25 | 5.25 | 6.5 | 7.8 | 5.0 | 6.8 | 4.7 | 4.3 |
| 26 | 5.2 | 6.1 | 7.5 | 5.0 | 6.6 | 4.7 | 4.2 |
| 27 | 5.2 | 5.8 | 6.3 | 5.0 | 5.65 | 4.7 | 4.2 |
| 28 | 5.1 | 5.65 | 6.3 | 5.0 | 5.4 | 4.6 | 4.2 |
| 29 | 5.05 | ..... | 6.3 | 4.9 | 5.25 | 4.6 | 4.2 |
| 30 | 5.0 | ..... | 6.4 | 4.9 | 5.1 | 4.6 | 4.2 |
| 31 | 5.0 | ..... | 7.8 | ..... | 5.0 | ..... | 4.2 |

*Rating table for Puta Creek near Guenoc, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 4.00 | 1 | 5.00 | 155 | 6.00 | 680 | 7.00 | 1,720 | 9.00 | 4,640 |
| 4.10 | 4 | 5.10 | 190 | 6.10 | 760 | 7.20 | 1,960 | 9.20 | 5,000 |
| 4.20 | 9 | 5.20 | 230 | 6.20 | 850 | 7.40 | 2,200 | 9.40 | 5,360 |
| 4.30 | 19 | 5.30 | 270 | 6.30 | 940 | 7.60 | 2,480 | 9.60 | 5,720 |
| 4.40 | 29 | 5.40 | 315 | 6.40 | 1,035 | 7.80 | 2,760 | 9.80 | 6,080 |
| 4.50 | 43 | 5.50 | 365 | 6.50 | 1,135 | 8.00 | 3,040 | 10.00 | 6,440 |
| 4.60 | 63 | 5.60 | 420 | 6.60 | 1,240 | 8.20 | 3,340 | 11.00 | 8,240 |
| 4.70 | 83 | 5.70 | 480 | 6.70 | 1,360 | 8.40 | 3,650 | 12.00 | 10,040 |
| 4.80 | 105 | 5.80 | 540 | 6.80 | 1,480 | 8.60 | 3,970 | 13.00 | 11,840 |
| 4.90 | 129 | 5.90 | 610 | 6.90 | 1,600 | 8.80 | 4,300 | | |

NOTE.—This table is based on discharge measurements made during 1906, and is well defined between gage heights 4.3 feet and 8 feet.

*Monthly discharge of Puta Creek near Guenoc, Cal., for 1906.*

[Drainage area, 91 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 12,300 | 0 | 1,800 | 111,000 | 19.78 | 22.81 |
| February | 2,200 | 105 | 727 | 40,400 | 7.99 | 8.32 |
| March | 3,190 | 230 | 916 | 56,300 | 10.07 | 11.61 |
| April | 940 | 105 | 302 | 18,000 | 3.32 | 3.70 |
| May | 1,480 | 105 | 215 | 13,200 | 2.36 | 2.72 |
| June | 365 | 63 | 165 | 9,820 | 1.81 | 2.02 |
| July | 63 | 9 | 26.8 | 1,650 | 0.294 | 0.34 |
| The period | ..... | ..... | ..... | 250,000 | ..... | ..... |

NOTE.—Discharges interpolated for days when gage was not read. Values are rated as follows: January and July, good; remainder of the period, excellent.

## PUTA CREEK AT WINTERS, CAL.

This station was established September 26, 1905. It is located about 450 feet below the Southern Pacific Railroad bridge and about 800 feet southeast of the depot at Winters, Cal. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, pages 182–182.

*Discharge measurements of Puta Creek at Winters, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 20 | R. S. Hawley | 178 | 1,240 | 9.90 | 3,820 |
| February 3 | F. R. S. Buttemer | 170 | 287 | 5.10 | 326 |
| February 15 | do | 182 | 1,300 | 10.55 | 4,660 |
| February 22 | do | 180 | 809 | 8.50 | 2,950 |
| March 6 | do | 178 | 410 | 7.02 | 1,460 |
| March 14 | do | 179 | 636 | 8.15 | 2,430 |
| May 4 | R. S. Hawley | 128 | 160 | 6.00 | 390 |
| May 15 | do | 123 | 146 | 5.80 | 287 |
| June 8 | do | 150 | 134 | 5.78 | 325 |
| July 5 | do | 80 | 75 | 4.90 | 107 |
| July 26 | do | 50 | 44 | 4.75 | 31 |
| July 27 | do | 50 | 46 | 4.75 | 34 |
| August 14 | do | 50 | 26 | 4.62 | 22 |
| August 15 | do | 50 | 24 | [a] 4.79 | 19.3 |
| September 8 | do | 50 | 20 | 4.70 | 14.5 |

[a] New gage; old gage reading 4.60 feet.

NOTE.—Measurements of May 4 and after were made by wading 200 feet above the cable.

*Daily gage height, in feet, of Puta Creek at Winters, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.60 | 5.28 | 6.58 | 10.00 | [a] 6.10 | 6.00 | 4.95 | 4.70 | 4.75 | 4.70 | 4.75 | 4.90 |
| 2 | 4.61 | 5.20 | 6.35 | 8.85 | [a] 6.10 | 5.80 | 4.90 | 4.70 | 4.75 | 4.70 | 4.70 | 4.90 |
| 3 | 4.62 | 5.10 | 11.20 | 8.00 | [a] 6.05 | 5.75 | 4.90 | 4.70 | 4.75 | 4.70 | 4.75 | 4.90 |
| 4 | 4.62 | 5.05 | 10.10 | 7.80 | 6.00 | 5.80 | 4.85 | 4.75 | 4.80 | 4.65 | 4.85 | [a] 4.90 |
| 5 | 4.63 | 5.00 | 7.62 | 7.50 | [a] 6.00 | 6.00 | 4.80 | 4.75 | 4.75 | 4.65 | 4.90 | 4.90 |
| 6 | 4.64 | 4.95 | 7.00 | 7.35 | 5.95 | 5.90 | 4.80 | 4.75 | 4.75 | 4.65 | 4.90 | 4.90 |
| 7 | 4.64 | 4.93 | 6.88 | 7.15 | 5.90 | 5.80 | 4.75 | 4.80 | 4.70 | 4.65 | 4.90 | [a] 4.95 |
| 8 | 4.63 | 4.90 | 6.60 | 7.05 | 5.90 | 5.80 | 4.75 | 4.80 | 4.70 | 4.65 | 4.95 | 5.00 |
| 9 | 4.64 | 4.87 | 6.45 | 6.95 | 5.85 | 5.70 | 4.65 | 4.80 | 4.70 | 4.65 | 4.95 | 4.90 |
| 10 | 4.64 | 4.85 | [a] 6.30 | 6.85 | 5.80 | 5.60 | 4.65 | 4.80 | 4.70 | [a] 4.70 | 4.90 | 5.20 |
| 11 | 4.66 | 4.90 | 6.20 | 6.75 | 5.80 | 5.60 | 4.65 | 4.75 | 4.70 | 4.70 | 4.90 | 10.70 |
| 12 | 4.85 | 5.00 | 11.40 | 6.70 | 5.80 | 5.55 | 4.60 | 4.85 | 4.70 | 4.75 | 4.90 | 6.95 |
| 13 | 10.76 | 4.90 | 9.05 | 6.60 | [a] 5.80 | 5.70 | 4.60 | 4.8 | [a] 4.70 | [a] 4.75 | 4.85 | 6.30 |
| 14 | 13.00 | 4.90 | 8.28 | 6.50 | 5.80 | 5.55 | 4.60 | 4.75 | 4.70 | 4.75 | 4.85 | 6.00 |
| 15 | 10.75 | 12.50 | 7.90 | 6.50 | 5.80 | 5.50 | 4.60 | [b] 4.80 | 4.70 | 4.70 | 4.85 | 5.75 |
| 16 | 21.60 | 7.33 | 7.38 | 6.50 | 5.85 | 5.50 | 4.60 | 4.75 | 4.70 | 4.70 | 4.85 | 5.70 |
| 17 | 12.20 | 6.60 | 7.12 | 6.40 | 5.80 | 5.45 | 4.55 | [a] 4.75 | 4.70 | 4.70 | 4.85 | 5.60 |
| 18 | 22.85 | 7.15 | 6.85 | 6.30 | 5.70 | 5.40 | 4.55 | 4.70 | 4.65 | 4.70 | 4.85 | 5.50 |
| 19 | 24.00 | 8.26 | 7.75 | 6.30 | 5.70 | 5.35 | 4.80 | 4.75 | 4.70 | 4.70 | 4.85 | 5.40 |
| 20 | 10.80 | 7.10 | 7.60 | 6.30 | 5.70 | 5.20 | 4.70 | 4.75 | 4.65 | 4.70 | 4.85 | 5.35 |
| 21 | 8.45 | 10.08 | 11.09 | 6.30 | 5.65 | 5.20 | 4.70 | 4.75 | [a] 4.70 | 4.65 | 4.85 | 5.30 |
| 22 | 7.30 | 8.60 | 8.75 | 6.25 | 5.60 | 5.10 | 4.75 | 4.75 | 4.70 | 4.65 | 4.85 | 5.30 |
| 23 | 6.91 | 7.55 | 9.65 | 6.30 | 5.60 | 5.10 | 4.75 | 4.70 | 4.70 | 4.70 | [a] 4.85 | 5.35 |
| 24 | 6.70 | 8.90 | 13.50 | 6.30 | 5.60 | 5.15 | 4.7 | 4.70 | 4.70 | 4.70 | 4.85 | [a] 5.35 |
| 25 | 6.35 | [a] 8.00 | 11.80 | 6.25 | 5.60 | 5.20 | 4.75 | 4.70 | 4.70 | 4.70 | 4.85 | 5.35 |
| 26 | 6.00 | 7.10 | 11.85 | 6.20 | 6.60 | 5.10 | 4.75 | 4.75 | 4.70 | 4.70 | 4.85 | 13.90 |
| 27 | 5.82 | 6.75 | 9.70 | 6.20 | [a] 6.80 | 5.30 | 4.75 | 4.70 | 4.70 | [a] 4.70 | 4.90 | 10.00 |
| 28 | 5.70 | 6.88 | 8.50 | 6.20 | 7.00 | 5.00 | 4.75 | 4.75 | [a] 4.70 | 4.70 | 4.90 | 7.35 |
| 29 | 5.55 | ..... | 7.88 | [a] 6.15 | 6.50 | 5.10 | 4.75 | [a] 4.75 | 4.70 | 4.75 | 4.90 | 6.75 |
| 30 | 5.45 | ..... | 8.50 | [a] 6.15 | 6.15 | 5.00 | 4.70 | 4.75 | 4.70 | 4.75 | 4.90 | 6.40 |
| 31 | 5.35 | ..... | 15.50 | ..... | 6.05 | ..... | 4.70 | 4.70 | ..... | 4.75 | ..... | 6.40 |

[a] Gage height estimated. [b] A new gage was put in August 15 and read after that date.

*Daily discharge, in second-feet, of Puta Creek at Winters, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 22 | 360 | 1,080 | 4,140 | 480 | 450 | 139 | 29 | 18 | 14 | 18 | 40 |
| 2 | 22 | 380 | 880 | 3,020 | 480 | 350 | 131 | 29 | 18 | 14 | 14 | 40 |
| 3 | 22 | 330 | 5,540 | 2,210 | 435 | 315 | 123 | 28 | 18 | 14 | 18 | 40 |
| 4 | 22 | 290 | 4,420 | 2,020 | 390 | 350 | 115 | 28 | 24 | 10 | 31 | 40 |
| 5 | 25 | 250 | 2,020 | 1,740 | 390 | 450 | 107 | 27 | 18 | 10 | 40 | 40 |
| 6 | 25 | 220 | 1,440 | 1,600 | 365 | 400 | 104 | 27 | 18 | 10 | 40 | 40 |
| 7 | 25 | 200 | 1,300 | 1,420 | 340 | 350 | 101 | 26 | 14 | 10 | 40 | 52 |
| 8 | 25 | 150 | 1,050 | 1,330 | 340 | 350 | 98 | 26 | 14 | 10 | 52 | 64 |
| 9 | 25 | 120 | 920 | 1,240 | 315 | 301 | 95 | 25 | 14 | 10 | 52 | 40 |
| 10 | 25 | 100 | 780 | 1,150 | 290 | 294 | 92 | 25 | 14 | 14 | 40 | 116 |
| 11 | 25 | 100 | 680 | 1,060 | 290 | 287 | 89 | 24 | 14 | 14 | 40 | 4,790 |
| 12 | 46 | 110 | 5,640 | 1,010 | 290 | 280 | 86 | 24 | 14 | 18 | 40 | 1,205 |
| 13 | 4,840 | 80 | 3,280 | 920 | 290 | 273 | 83 | 23 | 14 | 18 | 31 | 640 |
| 14 | 7,140 | 70 | 2,530 | 830 | 290 | 266 | 80 | 22 | 14 | 18 | 31 | 400 |
| 15 | 4,840 | 6,620 | 2,170 | 830 | 290 | 259 | 76 | 24 | 14 | 14 | 31 | 290 |
| 16 | 17,800 | 1,600 | 1,700 | 830 | 315 | 252 | 72 | 18 | 14 | 14 | 31 | 273 |
| 17 | 6,300 | 980 | 1,430 | 750 | 290 | 245 | 68 | 18 | 14 | 14 | 31 | 239 |
| 18 | 19,400 | 1,530 | 1,200 | 660 | 250 | 238 | 64 | 14 | 10 | 14 | 31 | 206 |
| 19 | 20,900 | 2,610 | 2,010 | 660 | 250 | 231 | 60 | 18 | 14 | 14 | 31 | 175 |
| 20 | 4,890 | 1,570 | 1,870 | 660 | 250 | 224 | 56 | 18 | 10 | 14 | 31 | 160 |
| 21 | 2,480 | 4,440 | 5,160 | 660 | 230 | 217 | 52 | 18 | 14 | 10 | 31 | 145 |
| 22 | 1,600 | 3,040 | 2,950 | 610 | 210 | 210 | 48 | 18 | 14 | 10 | 31 | 145 |
| 23 | 1,160 | 2,040 | 3,810 | 660 | 210 | 203 | 44 | 14 | 14 | 14 | 31 | 160 |
| 24 | 970 | 3,310 | 7,760 | 660 | 210 | 195 | 40 | 14 | 14 | 14 | 31 | 160 |
| 25 | 800 | 2,440 | 5,950 | 610 | 210 | 187 | 36 | 14 | 14 | 14 | 31 | 160 |
| 26 | 560 | 1,600 | 6,000 | 570 | 895 | 179 | 32 | 18 | 14 | 14 | 31 | 8,130 |
| 27 | 470 | 1,240 | 3,850 | 570 | 1,070 | 171 | 32 | 14 | 14 | 14 | 40 | 4,090 |
| 28 | 430 | 1,360 | 2,710 | 570 | 1,250 | 163 | 31 | 18 | 14 | 14 | 40 | 1,565 |
| 29 | 400 | ..... | 2,130 | 525 | 810 | 155 | 31 | 18 | 14 | 18 | 40 | 1,025 |
| 30 | 380 | ..... | 2,700 | 525 | 530 | 147 | 30 | 18 | 14 | 18 | 40 | 725 |
| 31 | 360 | ..... | 10,040 | ..... | 480 | ..... | 30 | 14 | ..... | 18 | ..... | 725 |

NOTE.—These discharges were obtained by the indirect method for shifting channels, except for the high water in January, which are based on a rating table, using high-water measurements made in January, 1907.

*Monthly discharge of Puta Creek at Winters, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 20,900 | 22 | 3,100 | 191,000 |
| February | 6,620 | 70 | 1,330 | 73,900 |
| March | 10,000 | 680 | 3,060 | 188,000 |
| April | 4,140 | 525 | 1,130 | 67,200 |
| May | 1,250 | 210 | 411 | 25,300 |
| June | 450 | 147 | 266 | 15,800 |
| July | 139 | 30 | 72.4 | 4,450 |
| August | 29 | 14 | 21.0 | 1,290 |
| September | 24 | 10 | 14.7 | 875 |
| October | 18 | 10 | 13.7 | 842 |
| November | 52 | 14 | 34.0 | 2,020 |
| December | 8,130 | 40 | 836 | 51,400 |
| The year | 20,900 | 10 | 857 | 622,000 |

NOTE.—The discharge for gage heights above 11 feet is based on measurements made in January, 1907. Values are rated fair.

## FEATHER RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Feather River drains a portion of the western slope of the Sierra Nevada extending east nearly to the Nevada State line, a distance of about 75 miles, and north and south for a distance of from 30 to 40 miles.

The greater portion of the watershed is rough and mountainous and has numerous tributaries which drain the slopes of the higher mountains. The formation in the southern and eastern part of the basin is of granite, with a comparatively deep soil covering. There is also a considerable area composed of lava and other volcanic matter in the northern part of the basin. Numerous meadows and valleys also exist, which tend to maintain a steady flow during the dry season. The soil is generally porous and absorbs the moisture readily. The entire watershed is well covered with a growth of brush and timber, much of which is large enough to make lumbering a profitable industry, with the exception of the meadow lands and valleys, which are used for stock ranges and grazing lands. There are numerous large springs, especially in the lava districts, which supply a more or less steady flow throughout the year. These are especially noticeable on North Fork, where there are perennial springs discharging from 50 to 100 second-feet. There is little artificial storage in the drainage area, and the water used for irrigation in the valleys is taken from the natural flow of the streams.

The mean annual precipitation is probably from 40 to 60 inches and is well distributed over the area. It falls largely in the form of snow, but disappears in the early part of the summer.

The drainage basin of North Fork of Feather River lies in the high sierra almost wholly in the northwestern portion of Plumas County. The junction of North Fork with East Fork, or Feather River proper, is in the western part of Plumas County, about 40 miles north of Oroville and 15 miles south of Prattville. The entire length of the North Fork basin does not exceed 40 miles, and its area is probably less than 1,000 square miles. This basin is rough and mountainous, though there are many large valley meadows above Prattville ranging in elevation from 4,000 to 6,000 feet. The formation consists of broken and porous lava and other volcanic matter, especially in the upper reaches, where numerous cones, craters, ashes, and lakes indicate recent volcanic activity. There is a good covering of porous soil, which absorbs moisture readily and equalizes the annual flow in the large number of tributaries in the basin. Except in the case of the highest peaks, like Lassen Peak, with elevation of 10,437 feet, which are rocky and barren, there is a good growth of timber and brush, and on the higher slopes this

growth becomes comparatively heavy and suitable for lumbering. A large per cent of the area, however, is meadow land, which permits profitable stock raising.

This basin has a mean annual precipitation of from 40 to 60 inches, a large percentage of which occurs as snow. A good portion of the rainfall and snow is collected and conserved in the numerous lakes on the higher elevations near the divide, but by far the greater percentage of the precipitation in this basin percolates through the porous surface soil into the vast beds of broken lava and volcanic gravels and sands beneath, where it is impounded in subterranean reservoirs. From the melting snows above and the perennial underground basins below a well-regulated flow issues from the highest reaches through the numerous mountain streams which gather into a few good-sized channels in the meadows below the higher elevations. These underground reservoirs also supply the many large perennial springs which issue from the borders of the meadows with discharges of from 50 to 100 second-feet. One of the largest of these springs is Dotta Spring, about 3 miles east of Prattville; it has a maximum discharge of 100 second-feet and a minimum of 70 second-feet.

As yet no irrigation or power developments of importance have been made, but the Great Western Power Company has carefully investigated the stream flow near Prattville and the storage possibilities in a portion of Big Meadows with a view to early development.

The watershed above Prattville is divided into two smaller basins of almost equal size, the eastern basin being drained by what is known as Hamilton Branch and its tributaries and the western basin by North Fork and its tributaries. The eastern basin ranges in elevation from 4,300 to 7,500 feet, has an area of 230 square miles, and includes the East Arm of Big Meadows and the large, level area called Mountain Meadows, but its run-off is only about half as large as that from the western basin, which has an area of 245 square miles varying in elevation from 4,300 to 10,000 feet and including the West Arm of Big Meadows and the higher elevations about Lassen Peak. Hamilton Branch and North Fork unite about 3 miles east of Prattville in the lower edge of Big Meadows. A gaging station is maintained on each stream a short distance above the point of confluence.

For the purpose of studying the water resources of North Fork of Feather River the Great Western Power Company has established and maintained a number of regular stations in the basin at which complete records are kept. These stations were established in the summer of 1905 by W. E. Spear under the direction of John R. Freeman, consulting engineer for the company. During 1906 they were maintained by L. J. Bevan under the direction of Vielé, Cooper & Blackwell, consulting engineers for the company.

## FEATHER RIVER AT OROVILLE, CAL.

This station was established January 1, 1902. It is located at the northeast edge of the town of Oroville, Cal., where Feather River breaks from the foothills on the western slope of the Sierra Nevada into Sacramento Valley. The drainage area is 3,640 square miles. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 155, where are given also references to publications that contain data for previous years.

*Discharge measurements of Feather River at Oroville, Cal., by Hawley and Sawyer, in 1906.*

| Date. | Width. | Area of section. | Gage height.[a] | Discharge. | Date. | Width. | Area of section. | Gage height.[a] | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 16 | 291 | 4,630 | 9.00 | 11,500 | May 2 | 309 | 4,760 | 10.88 | 18,800 |
| February 28 | 311 | 5,340 | 11.35 | 19,600 | May 11 | 312 | 5,270 | 11.95 | 22,100 |
| March 15 | 307 | 5,200 | 10.90 | 18,400 | May 17 | 298 | 4,280 | 9.30 | 12,600 |
| March 22 | 316 | 5,810 | 12.72 | 23,000 | July 6 | 279 | 3,240 | 6.25 | 7,190 |
| March 25 | 340 | 7,280 | 17.00 | 48,600 | July 26 | 273 | 2,380 | 3.10 | 2,860 |
| April 11 | 309 | 4,830 | 11.25 | 18,400 | September 5 | 272 | 2,100 | 1.90 | 1,760 |
| April 16 | 309 | 4,840 | 11.14 | 18,100 | October 12 | 271 | 2,060 | 1.73 | 1,620 |
| April 25 | 307 | 4,620 | 10.61 | 17,000 | November 1 | 272 | 2,060 | 1.73 | 1,610 |
| April 25 | 307 | 4,560 | 10.42 | 16,600 | December 10 | 274 | 2,410 | 3.05 | 3,270 |

[a] Gage heights refer to the gage at the station.

*Daily gage height, in feet, of Feather River at Oroville, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.95 | 5.45 | 10.4 | 14.7 | 10.65 | 10.7 | 6.1 | 2.95 | 2.05 | 1.8 | 1.8 | 1.9 |
| 2 | .95 | 5.0 | 9.5 | 13.3 | 10.95 | 10.35 | 6.0 | 2.9 | 2.0 | 1.8 | 1.8 | 1.9 |
| 3 | .9 | 4.7 | 9.5 | 13.1 | 11.85 | 11.1 | 6.8 | 2.9 | 2.0 | 1.8 | 2.5 | 1.9 |
| 4 | .95 | 4.7 | 9.4 | 12.6 | 11.5 | 13.0 | 6.55 | 2.85 | 1.95 | 1.8 | 6.95 | 1.9 |
| 5 | .85 | 4.75 | 9.6 | 12.1 | 12.0 | 11.7 | 6.45 | 2.8 | 1.9 | 1.8 | 5.25 | 1.9 |
| 6 | .85 | 5.2 | 8.4 | 12.2 | 12.05 | 11.3 | 6.65 | 2.8 | 1.9 | 1.8 | 3.5 | 1.9 |
| 7 | .85 | 5.3 | 8.3 | 10.35 | 12.2 | 10.6 | 6.55 | 2.75 | 1.9 | 1.8 | 2.5 | 1.9 |
| 8 | .85 | 5.35 | 8.3 | 10.15 | 12.05 | 9.6 | 6.4 | 2.7 | 1.9 | 1.8 | 2.0 | [a] 3.3 |
| 9 | .9 | 5.45 | 8.15 | 10.15 | 12.1 | 10.45 | 6.3 | 2.7 | 1.85 | 1.8 | 2.0 | 4.7 |
| 10 | 1.0 | 5.6 | 8.1 | 11.4 | 12.05 | 9.95 | 6.1 | 2.65 | 1.85 | 1.8 | 2.0 | 6.65 |
| 11 | 1.3 | 5.65 | 8.3 | 11.1 | 11.7 | 10.25 | 6.1 | 2.6 | 1.85 | 1.8 | 2.0 | 9.85 |
| 12 | 4.3 | 5.75 | 8.4 | 11.4 | 11.45 | 10.3 | 5.6 | 2.6 | 1.85 | 1.8 | 2.0 | 6.65 |
| 13 | 8.2 | 5.85 | 11.2 | 10.75 | 10.75 | 11.1 | 5.45 | 2.55 | 1.85 | 1.8 | 2.0 | 5.65 |
| 14 | 9.45 | 8.5 | 10.3 | 10.85 | 10.25 | 10.8 | 5.35 | 2.55 | 1.9 | 1.8 | 2.0 | 5.25 |
| 15 | 9.35 | 9.9 | 10.85 | 11.1 | 11.55 | 9.75 | 5.6 | 2.5 | 1.9 | 1.8 | 2.0 | 4.15 |
| 16 | 18.1 | 9.1 | 10.4 | 11.1 | 10.35 | 9.55 | 5.8 | 2.5 | 1.9 | 1.8 | 2.0 | 4.15 |
| 17 | 13.4 | 8.35 | 9.6 | 11.15 | 9.45 | 10.5 | 5.9 | 2.45 | 1.9 | 1.8 | 2.0 | 3.3 |
| 18 | 24.9 | 10.65 | 9.55 | 11.1 | 9.9 | 9.8 | 4.0 | 2.45 | 1.9 | 1.8 | 2.0 | 3.3 |
| 19 | 21.7 | 11.4 | 9.4 | 11.15 | 9.4 | 9.6 | 4.2 | 2.4 | 1.9 | 1.8 | 2.0 | 3.05 |
| 20 | 14.75 | 11.0 | 11.2 | 11.45 | 9.05 | 9.25 | 4.5 | 2.4 | 1.85 | 1.8 | 2.0 | 2.95 |
| 21 | 12.2 | 11.05 | 11.3 | 11.4 | 9.4 | 9.75 | 4.5 | 2.35 | 1.8 | 1.8 | 2.0 | 2.85 |
| 22 | 10.1 | 11.15 | 11.35 | 11.75 | 8.65 | 8.75 | 4.65 | 2.3 | 1.8 | 1.8 | 2.0 | 3.4 |
| 23 | 8.9 | 10.9 | 13.0 | 12.05 | 8.65 | 8.7 | 4.8 | 2.3 | 1.8 | 1.8 | 2.0 | 4.05 |
| 24 | 8.1 | 10.65 | 17.1 | 11.75 | 8.45 | 7.85 | 4.8 | 2.25 | 1.8 | [a] 1.8 | 2.0 | 4.05 |
| 25 | 7.4 | 10.9 | 17.1 | 11.0 | 9.0 | 7.8 | 3.95 | 2.25 | 1.85 | 1.8 | [a] 2.0 | 10.95 |
| 26 | 7.0 | 10.55 | 17.95 | 10.6 | 12.1 | 7.7 | 3.1 | 2.2 | 1.8 | [a] 1.8 | 1.95 | 16.25 |
| 27 | 6.2 | 11.2 | 15.55 | 10.1 | 12.25 | 7.6 | 3.1 | 2.2 | 1.8 | 1.8 | 1.95 | 12.45 |
| 28 | 6.25 | 11.6 | 14.75 | 10.25 | 12.85 | 7.1 | 3.05 | 2.15 | 1.8 | 1.8 | 1.95 | 9.55 |
| 29 | 6.2 | ..... | 13.6 | 9.95 | 11.7 | 6.9 | 3.05 | 2.15 | 1.8 | 1.8 | 1.95 | 7.95 |
| 30 | 6.2 | ..... | 15.8 | 10.0 | 11.0 | 6.75 | 3.0 | 2.1 | 1.8 | [a] 1.8 | 1.9 | 7.4 |
| 31 | 6.0 | ..... | 17.65 | ..... | ..... | ..... | 3.0 | 2.1 | ..... | 1.8 | ..... | 7.2 |

[a] Estimated.

NOTE.—These gage heights are for the station gage, 1,000 feet upstream from the bridge gage, at which readings were made during 1905. The gage at the station was read from March 1 to July 24, 1906. From January 1 to February 28 and from September 5 to December 31 the gage at the bridge was read; these readings have been reduced to equivalent readings at the station gage. From July 25 to September 4 no readings were made and the gage heights have been estimated.

*Rating table for Feather River at Oroville, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.75 | 1,200 | 2.00 | 2,060 | 3.30 | 3,260 | 5.20 | 5,300 | 11.00 | 17,600 |
| .80 | 1,230 | 2.10 | 2,140 | 3.40 | 3,360 | 5.40 | 5,540 | 12.00 | 21,500 |
| .90 | 1,295 | 2.20 | 2,220 | 3.50 | 3,460 | 5.60 | 5,780 | 13.00 | 26,000 |
| 1.00 | 1,360 | 2.30 | 2,310 | 3.60 | 3,560 | 5.80 | 6,020 | 14.00 | 31,000 |
| 1.10 | 1,430 | 2.40 | 2,400 | 3.70 | 3,660 | 6.00 | 6,260 | 15.00 | 36,500 |
| 1.20 | 1,500 | 2.50 | 2,490 | 3.80 | 3,760 | 6.20 | 6,520 | 16.00 | 42,000 |
| 1.30 | 1,570 | 2.60 | 2,580 | 3.90 | 3,860 | 6.40 | 6,780 | 17.00 | 47,500 |
| 1.40 | 1,640 | 2.70 | 2,670 | 4.00 | 3,960 | 6.60 | 7,050 | 18.00 | 53,500 |
| 1.50 | 1,710 | 2.80 | 2,760 | 4.20 | 4,180 | 6.80 | 7,330 | 19.00 | 59,500 |
| 1.60 | 1,780 | 2.90 | 2,860 | 4.40 | 4,400 | 7.00 | 7,640 | 20.00 | 65,500 |
| 1.70 | 1,850 | 3.00 | 2,960 | 4.60 | 4,620 | 8.00 | 9,450 | 21.00 | 71,700 |
| 1.80 | 1,920 | 3.10 | 3,060 | 4.80 | 4,840 | 9.00 | 11,600 | | |
| 1.90 | 1,990 | 3.20 | 3,160 | 5.00 | 5,060 | 10.00 | 14,260 | | |

NOTE.—This table is based on discharge measurements made during 1904–1906, and is well defined below gage height 17 feet.

*Monthly discharge of Feather River at Oroville, Cal., for 1906.*

[Drainage area, 3,640 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 96,300 | 1,240 | 14,500 | 892,000 | 3.98 | 4.59 |
| February | 19,900 | 4,730 | 11,100 | 616,000 | 3.05 | 3.18 |
| March | 53,200 | 9,640 | 21,600 | 1,330,000 | 5.93 | 6.84 |
| April | 34,800 | 14,100 | 19,200 | 1,140,000 | 5.27 | 5.88 |
| May | 25,300 | 10,300 | 17,500 | 1,080,000 | 4.81 | 5.54 |
| June | 26,000 | 7,260 | 13,800 | 821,000 | 3.79 | 4.23 |
| July | 7,330 | 2,960 | 5,240 | 322,000 | 1.44 | 1.66 |
| August | 2,910 | 2,140 | 2,490 | 153,000 | .684 | .79 |
| September | 2,100 | 1,920 | 1,970 | 117,000 | .541 | .60 |
| October | 1,920 | 1,920 | 1,920 | 118,000 | .527 | .61 |
| November | 7,560 | 1,920 | 2,410 | 143,000 | .662 | .74 |
| December | 43,400 | 1,990 | 7,070 | 435,000 | 1.94 | 2.24 |
| The year | 96,300 | 1,240 | 9,900 | 7,170,000 | 2.72 | 36.90 |

NOTE.—Values are rated as follows: January to June, and September, good; remainder of 1906 fair, as gage heights may be liable to error.

## GRIZZLY CREEK NEAR BECKWITH, CAL.

Grizzly Creek is tributary to the Middle Fork of Feather River from the north, and has a small drainage basin. There is a reservoir site in this basin which has already been surveyed by the Reclamation Service, and gagings on Grizzly Creek are of utility in determining storage possibilities.

This station was established December 17, 1905. It is located at Reno camp, about 4 miles west of Beckwith and 1 mile above Willow Glen Hotel. It is about 1,500 feet below the falls, the present terminus of the Boca and Loyalton Railroad, and is reached by driving from Beckwith. The drainage area above the station is 51 square miles.

The channel is straight for about 200 feet above and below the measuring section. The current is rather sluggish at low water but swift at high stages. The right bank is high and rocky and can not be overflowed. The left bank is low and overgrown with cottonwoods near the water's edge, and may be overflowed at high water. The bed of the stream is rocky and not subject to material change.

Discharge measurements are made from a car on a cable. The cable is anchored to a pine stump on the right bank, while on the left bank it is supported by a tower and is anchored by means of a large rock buried in the ground at a depth of 4 feet. The initial point for soundings is the near side of the pine stump supporting the cable.

The gage is 2 by 4 inches vertical timber, graduated to feet and tenths, and nailed securely to a large cottonwood tree about 800 feet above cable and 200 feet below the Reno camp boarding house. The bench mark is a spike in the root of the tree to which the gage is fastened; elevation, 4 feet above the zero of the gage.

*Discharge measurements of Grizzly Creek at Beckwith, Cal.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| December 17[a] | R. S. Hawley | 4 | 1.8 | 0.55 | 3.1 |
| 1906. | | | | | |
| May 26 | Hawley and Hardy | 37 | 70 | 2.50 | 211 |
| June 6 | W. N. Hardy | 36 | 61 | 2.30 | 201 |
| June 14 | do | 34 | 41 | 1.70 | 96 |
| June 22 | do | 34 | 39 | 1.48 | 65 |
| June 28 | do | 34 | 32 | 1.30 | 43 |
| July 7 | do | 32 | 24 | .92 | 24 |
| July 16 | do | [b] 6 | [b] 4.8 | .42 | 5.1 |
| July 25 | do | [b] 2 | [b] 1.6 | .41 | 3.2 |
| August 8 | do | [b] 1.6 | [b] 0.6 | .22 | .7 |
| August 12 | do | [b] 2.0 | [b] 1.6 | .40 | 3.2 |

[a] Ice 5 inches thick at the gage. [b] Wading section.

*Daily gage height, in feet, of Grizzly Creek near Beckwith, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.55 | 1.90 | 1.60 | 3.10 | ..... | ..... | 1.10 | 0.34 | 0.15 |
| 2 | .55 | 2.10 | 1.60 | 2.80 | ..... | ..... | 1.10 | .33 | .15 |
| 3 | .55 | 2.30 | 1.65 | 2.35 | ..... | ..... | 1.05 | .32 | .15 |
| 4 | .55 | 1.65 | 1.65 | 2.45 | ..... | ..... | 1.00 | .30 | .15 |
| 5 | .55 | 1.85 | 1.50 | 2.50 | ..... | ..... | 1.00 | .26 | .15 |
| 6 | .55 | 1.85 | 1.50 | 2.50 | ..... | 2.30 | 1.00 | .26 | .15 |
| 7 | .55 | 1.90 | 1.65 | 2.90 | ..... | 2.40 | 0.90 | .25 | .15 |
| 8 | .55 | 2.00 | 1.65 | 3.60 | ..... | 1.80 | 0.90 | .25 | .15 |
| 9 | .70 | 2.15 | 1.65 | 3.60 | ..... | 1.70 | 0.90 | .25 | .15 |
| 10 | .70 | 2.10 | 1.65 | 3.85 | ..... | 1.70 | 0.80 | .25 | .15 |
| 11 | .90 | 2.00 | 1.95 | 3.80 | ..... | 1.75 | 0.75 | .25 | .15 |
| 12 | .80 | 2.00 | 2.45 | 3.80 | ..... | 1.70 | 0.70 | .20 | .20 |
| 13 | 1.00 | 1.80 | 2.30 | 3.90 | ..... | 1.70 | 0.60 | .20 | .20 |
| 14 | 1.00 | 1.80 | 2.15 | 4.10 | ..... | 1.70 | 0.50 | .20 | .25 |
| 15 | .80 | 1.75 | 1.85 | 4.10 | ..... | 2.30 | 0.50 | .20 | .20 |
| 16 | 1.00 | 1.80 | 1.85 | 4.20 | ..... | 1.60 | 0.50 | .20 | .20 |
| 17 | 1.60 | 1.85 | 1.85 | 4.20 | ..... | 1.70 | 0.45 | .20 | .20 |
| 18 | 1.80 | 1.85 | 1.80 | 4.10 | ..... | 1.65 | 0.42 | .20 | .20 |
| 19 | 2.00 | 1.85 | 1.85 | 4.10 | ..... | 1.60 | 0.42 | .30 | .20 |
| 20 | 1.40 | 1.85 | 1.85 | 4.00 | ..... | 1.50 | 0.42 | .20 | .20 |
| 21 | 1.00 | 1.85 | 1.90 | 3.60 | ..... | 1.40 | 0.42 | .15 | .20 |
| 22 | .70 | 1.75 | 2.15 | 3.60 | ..... | 1.40 | 0.42 | .15 | .20 |
| 23 | .90 | 1.75 | 2.20 | 3.40 | ..... | 1.40 | 0.41 | .15 | .20 |
| 24 | .90 | 1.85 | 2.65 | 3.40 | ..... | 1.40 | 0.41 | .15 | .20 |
| 25 | 1.20 | 1.95 | 2.60 | 3.80 | ..... | 1.40 | 0.41 | .15 | .25 |
| 26 | 1.10 | 1.80 | 2.60 | ..... | 2.50 | 1.35 | 0.41 | .15 | .25 |
| 27 | 1.55 | 1.65 | 2.65 | ..... | ..... | 1.30 | 0.41 | .15 | .25 |
| 28 | 1.40 | 1.65 | 2.70 | ..... | ..... | 1.20 | 0.40 | .15 | .25 |
| 29 | 1.40 | ..... | 2.80 | ..... | ..... | 1.20 | 0.40 | .15 | .25 |
| 30 | 1.90 | ..... | 2.85 | ..... | ..... | 1.15 | 0.36 | .15 | .25 |
| 31 | 2.40 | ..... | 3.10 | ..... | ..... | ..... | 0.34 | .15 | ..... |

*Rating table for Grizzly Creek near Beckwith, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.10 | 0 | 0.90 | 22 | 1.70 | 87 | 2.50 | 225 | 3.60 | 489 |
| 0.20 | 0.5 | 1.00 | 28 | 1.80 | 98 | 2.60 | 249 | 3.80 | 537 |
| 0.30 | 1.6 | 1.10 | 34 | 1.90 | 110 | 2.70 | 273 | 4.00 | 585 |
| 0.40 | 3.2 | 1.20 | 42 | 2.00 | 124 | 2.80 | 297 | 4.20 | 633 |
| 0.50 | 5.5 | 1.30 | 50 | 2.10 | 141 | 2.90 | 321 | 4.40 | 681 |
| 0.60 | 9 | 1.40 | 58 | 2.20 | 159 | 3.00 | 345 | 4.60 | 729 |
| 0.70 | 13 | 1.50 | 67 | 2.30 | 179 | 3.20 | 393 | 4.80 | 777 |
| 0.80 | 17 | 1.60 | 77 | 2.40 | 202 | 3.40 | 441 | 5.00 | 825 |

NOTE.—The above table is strictly applicable only for open-channel conditions. It is based on 10 discharge measurements made during 1906 and is well defined between gage heights 0.2 foot and 2.5 feet.

*Monthly discharge of Grizzly Creek near Beckwith, Cal., for 1906.*

[Drainage area, 51 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 202 | 7 | 40 | 2,460 | 0.784 | 0.90 |
| February | 179 | 82 | 110 | 6,110 | 2.16 | 2.24 |
| March | 369 | 67 | 153 | 9,410 | 3.00 | 3.46 |
| April 1-25 | 681 | 190 | 469 | 23,300 | 9.20 | 8.55 |
| June 6-30 | 202 | 38 | 83.6 | 4,150 | 1.64 | 1.52 |
| July | 34 | 2.2 | 11.9 | 732 | .234 | .27 |
| August | 2.2 | 0.2 | 0.73 | 45 | .014 | .02 |
| September | 1 | 0.2 | 0.51 | 30 | .010 | .01 |
| The period | | | | 46,200 | | |

NOTE.—Values are rated as fair, except January and February, which are liable to greater error on account of ice conditions.

## INDIAN CREEK NEAR CRESCENT MILLS, CAL.

Indian Creek is a tributary from the east to North Fork of Feather River, entering below the Prattville station; it has a considerable drainage basin. A reservoir site has been surveyed by the Reclamation Service, and measurements are of utility in computing storage possibilities.

The station was established November 29, 1905. It is located about 1¼ miles from Crescent Mills on the Greenville-Quincy road, and is most easily reached by driving from Taylorsville, a distance of 5 miles. It is 2,000 feet below the Arlington Bridge and near E. Cook's residence.

The channel is straight for 1,000 feet above and 200 feet below, and the current is very sluggish. Both banks are high and not liable to overflow. They are covered by a thick growth of brush up to the high-water line and above this by oaks and pines. The bed of the stream is composed of silt and is not liable to change materially. At low water the maximum depth is about 12 feet. Discharge measurements are made from a car on a cable. The initial point for soundings is the oak stump to which the cable is fastened on the right bank.

The gage is a vertical 2 by 6 inch timber, graduated to feet and tenths, and is in two sections. It is on the right bank about 20 feet above the cable. The lower section is about 5 feet long and is fastened to an overhanging willow; the upper section is about 10 feet in length and is fastened to a cottonwood tree. The bench mark is a spike driven in the cottonwood tree to which the high-water gage is attached; elevation, 8.00 feet above the zero of the gage.

*Discharge measurements of Indian Creek at Crescent Mills, Cal., by Hawley and Hardy, in 1905–6.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| 1905. | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | 1906. | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| December 14 | 45 | 66 | 1.35 | 76 | July 3 | 180 | 1,570 | 3.32 | 367 |
| | | | | | July 11 | 67 | 288 | 2.45 | 268 |
| 1906. | | | | | July 20 | 65 | 211 | 1.70 | 129 |
| May 29 | 190 | 2,080 | 6.25 | 1,940 | July 30 | 65 | 184 | 1.35 | 77 |
| May 31 | 186 | 1,960 | 5.56 | 1,580 | August 6 | 65 | 172 | 1.12 | 50 |
| June 9 | 182 | 1,850 | 4.87 | 1,120 | August 17 | 64 | 176 | 1.20 | 55 |
| June 18 | 182 | 1,810 | 4.69 | 1,020 | August 27 | 64 | 171 | 1.05 | 40 |
| June 25 | 181 | 1,680 | 3.80 | 608 | September 9 | 64 | 171 | 1.10 | 44 |

NOTE.—These measurements were made at different sections.

*Daily gage height, in feet, of Indian Creek at Crescent Mills, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.45 | 3.15 | 5.75 | 8.45 | 6.4 | 5.4 | 3.3 | 1.25 | 1.1 | 1.5 | 1.45 | 1.45 |
| 2 | 1.5 | 3.0 | 5.15 | 7.35 | 6.5 | 5.4 | 3.3 | 1.15 | 1.1 | 1.5 | 1.45 | 1.45 |
| 3 | 1.5 | 3.0 | 5.15 | 6.7 | 6.8 | 5.3 | 3.3 | 1.1 | 1.15 | 1.45 | 1.55 | 1.5 |
| 4 | 1.5 | 2.95 | 4.95 | 6.3 | 6.95 | 5.5 | 3.25 | 1.1 | 1.15 | 1.45 | 2.2 | 1.5 |
| 5 | 1.5 | 2.95 | 4.7 | 5.95 | 7.1 | 5.5 | 3.1 | 1.1 | 1.15 | 1.45 | 2.8 | 1.5 |
| 6 | 1.5 | 2.95 | 4.45 | 6.0 | 7.0 | 5.35 | 3.0 | 1.1 | 1.15 | 1.45 | 2.35 | 1.5 |
| 7 | 1.5 | 2.95 | 4.45 | 6.5 | 6.9 | 5.15 | 2.9 | 1.1 | 1.15 | 1.45 | 2.0 | 1.55 |
| 8 | 1.45 | 2.95 | 4.6 | 7.0 | 6.8 | 4.95 | 2.8 | 1.4 | 1.15 | 1.45 | 1.85 | 1.75 |
| 9 | 1.5 | 2.95 | 5.0 | 7.5 | 6.7 | 4.9 | 2.7 | 1.3 | 1.1 | 1.5 | 1.8 | 1.9 |
| 10 | 1.5 | 3.0 | 5.3 | 7.7 | 6.75 | 4.9 | 2.6 | 1.2 | 1.1 | 1.5 | 1.7 | 3.5 |
| 11 | 1.6 | 3.0 | 5.8 | 7.6 | 6.8 | 4.9 | 2.4 | 1.2 | 1.1 | 1.5 | 1.65 | 3.5 |
| 12 | 2.3 | 3.0 | 7.8 | 7.3 | 6.8 | 4.95 | 2.3 | 1.15 | 1.15 | 1.5 | 1.65 | 4.2 |
| 13 | 2.9 | 3.05 | 8.0 | 7.1 | 6.4 | 4.95 | 2.3 | 1.25 | 1.15 | 1.5 | 1.6 | 3.6 |
| 14 | 3.95 | 3.4 | 6.9 | 7.1 | 6.2 | 4.8 | 2.2 | 1.35 | 1.15 | 1.5 | 1.6 | 3.3 |
| 15 | 2.8 | 3.6 | 6.1 | 7.3 | 6.1 | 4.7 | 2.2 | 1.25 | 1.2 | 1.5 | 1.6 | 3.0 |
| 16 | 7.1 | 4.6 | 5.6 | 7.5 | 5.8 | 4.75 | 2.0 | 1.2 | 1.25 | 1.5 | 1.7 | 2.8 |
| 17 | 7.1 | 4.3 | 5.3 | 7.7 | 5.4 | 4.8 | 1.9 | 1.2 | 1.25 | 1.5 | 1.75 | 2.65 |
| 18 | 9.22 | 4.35 | 5.0 | 7.6 | 5.1 | 4.65 | 1.9 | 1.2 | 1.25 | 1.5 | 1.7 | 2.55 |
| 19 | 10.68 | 5.1 | 4.7 | 7.5 | 4.9 | 4.5 | 1.8 | 1.15 | 1.25 | 1.5 | 1.6 | 2.45 |
| 20 | 7.5 | 5.5 | 4.6 | 7.6 | 4.9 | 4.4 | 1.7 | 1.15 | 1.2 | 1.5 | 1.6 | 2.4 |
| 21 | 5.45 | 6.1 | 4.9 | 7.7 | 4.8 | 4.35 | 1.6 | 1.05 | 1.15 | 1.5 | 1.6 | 2.35 |
| 22 | 4.5 | 5.7 | 5.9 | 7.8 | 4.7 | 4.25 | 1.55 | 1.05 | 1.15 | 1.5 | 1.6 | 2.35 |
| 23 | 4.15 | 5.2 | 6.95 | 7.65 | 4.6 | 4.0 | 1.5 | 1.05 | 1.15 | 1.5 | 1.6 | 2.5 |
| 24 | 3.8 | 4.9 | 8.1 | 7.25 | 4.5 | 3.85 | 1.5 | 1.05 | 1.2 | 1.5 | 1.55 | 2.75 |
| 25 | 3.45 | 4.65 | 8.85 | 6.8 | 4.5 | 3.8 | 1.5 | 1.1 | 1.25 | 1.5 | 1.55 | 4.6 |
| 26 | 3.4 | 4.5 | 8.9 | 6.35 | 5.1 | 3.75 | 1.45 | 1.2 | 1.3 | 1.45 | 1.55 | 6.9 |
| 27 | 3.3 | 5.5 | 8.58 | 6.1 | 5.75 | 3.7 | 1.45 | 1.2 | 1.3 | 1.45 | 1.5 | 6.85 |
| 28 | 3.3 | 6.6 | 7.85 | 6.1 | 6.25 | 3.6 | 1.4 | 1.05 | 1.35 | 1.45 | 1.5 | 5.4 |
| 29 | 3.3 | ..... | 7.35 | 6.15 | 6.15 | 3.5 | 1.35 | 1.05 | 1.4 | 1.45 | 1.5 | 4.6 |
| 30 | 3.2 | ..... | 7.25 | 6.3 | 5.75 | 3.4 | 1.35 | 1.1 | 1.4 | 1.4 | 1.5 | 4.1 |
| 31 | 3.1 | ..... | 8.58 | ..... | 5.55 | ..... | 1.35 | 1.1 | ..... | 1.4 | ..... | 4.2 |

*Rating table for Indian Creek at Crescent Mills, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.00 | 35 | 2.00 | 182 | 3.00 | 395 | 4.00 | 700 | 6.00 | 1,800 |
| 1.10 | 46 | 2.10 | 200 | 3.10 | 421 | 4.20 | 785 | 6.20 | 1,940 |
| 1.20 | 58 | 2.20 | 219 | 3.20 | 448 | 4.40 | 880 | 6.40 | 2,080 |
| 1.30 | 71 | 2.30 | 238 | 3.30 | 475 | 4.60 | 980 | 6.60 | 2,220 |
| 1.40 | 84 | 2.40 | 258 | 3.40 | 502 | 4.80 | 1,080 | 6.80 | 2,360 |
| 1.50 | 98 | 2.50 | 278 | 3.50 | 530 | 5.00 | 1,180 | 7.00 | 2,500 |
| 1.60 | 113 | 2.60 | 299 | 3.60 | 560 | 5.20 | 1.300 | 8.00 | 3,200 |
| 1.70 | 129 | 2.70 | 321 | 3.70 | 595 | 5.40 | 1,420 | 9.00 | 3,900 |
| 1.80 | 146 | 2.80 | 345 | 3.80 | 630 | 5.60 | 1,540 | 10.00 | 4,600 |
| 1.90 | 164 | 2.90 | 369 | 3.90 | 665 | 5.80 | 1,660 | 11.00 | 5,300 |

NOTE.—This table is based on 14 discharge measurements made during 1905–6, and is well defined below gage height 6.2 feet.

*Monthly discharge of Indian Creek at Crescent Mills, Cal., for 1906.*

[Drainage area, 740 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 5,080 | 91 | 868 | 53,400 | 1.17 | 1.35 |
| February | 2,220 | 382 | 824 | 45,800 | 1.11 | 1.16 |
| March | 3,830 | 905 | 2,000 | 123,000 | 2.70 | 3.11 |
| April | 3,520 | 1,760 | 2,550 | 152,000 | 3.45 | 3.85 |
| May | 2,570 | 930 | 1,790 | 110,000 | 2.42 | 2.79 |
| June | 1,480 | 502 | 1,010 | 60,100 | 1.36 | 1.52 |
| July | 475 | 78 | 226 | 13,900 | 0.305 | 0.35 |
| August | 84 | 40 | 53.1 | 3,260 | 0.072 | .08 |
| September | 84 | 46 | 57.9 | 3,450 | 0.078 | .09 |
| October | 98 | 84 | 94.8 | 5,830 | 0.128 | .15 |
| November | 345 | 91 | 132 | 7,860 | 0.178 | .20 |
| December | 2,430 | 91 | 534 | 32,800 | 0.722 | .83 |
| The year | 5,080 | 40 | 845 | 611,000 | 1.14 | 15.48 |

NOTE.—These values are excellent.

## NORTH FORK OF FEATHER RIVER BELOW PRATTVILLE, CAL.

This station was established November 22, 1905. Previous to that date, however, the Great Western Power Company had installed a gage rod and maintained a daily record since June 13, 1905, making gagings by means of a boat. This station is located in the canyon at the proposed dam site of the Great Western Power Company, about 3 miles below the Meadow View bridge crossing on the Prattville-Greenville road, and about 5 miles southeast of Prattville. The drainage area above this point is only 506 square miles, but the run-off during the months of low flow is about half the total run-off at the Oroville station from a drainage area of 3,640 square miles.

The equipment for gaging at this station consists of a $\frac{5}{8}$-inch cable anchored to a large rock on the left bank and to a spruce tree on the right, having a clear span of 155 feet and supporting a car with a lock box. Parallel to the cable and 35 feet upstream a guy wire spans the channel for staying the meter in the higher stages. The cable is marked with a ring of white paint every 5 feet for conven-

ience in sounding, and the initial point is an iron bolt in the root of the tree supporting the cable. The car is used for making measurements at all stages. The gage rod is inclosed in the clock register well, which is on the right bank about 700 feet above the cable. The well, which protects the gage from the thin surface ice in winter, is lined on the inside with building paper to prevent freezing and is provided with a hinged door on the river side to permit easy access for reading direct and comparison with clock register. The reference bench mark is a point surrounded by a ring of white paint on a rock 8 feet southwest of the gage; elevation, 7.62 feet above the zero of the gage.

The channel is straight for 400 feet above the cable and for 200 feet below. The bed is rocky and not liable to change materially. Both banks are high and steep and not subject to overflow at any stage. There is a growth of small willows along the water's edge and for a short distance back of it, while higher up are found spruce and fir trees. The stream is in one channel at all stages and is swift in high water, but has moderate velocity at other times. The cross section is regular and not subject to much change, the width of the stream being about 60 feet at low water with a maximum depth of 9 feet.

This station is maintained in cooperation with the Great Western Power Company, whose hydrographer, Mr. L. J. Bevan, has kept the gage-height record and made meter measurements since it was established in 1905. The data collected at this point indicates the quantity of water that could be impounded in the proposed Big Meadows reservoir, and the water thus stored would be available for power and irrigation and could be utilized in the control of Sacramento River.

*Discharge measurements of North Fork of Feather River below Prattville, Cal., in 1905–6.*

| Date. | Hydrographer. | Gage height. | Discharge. | Date. | Hydrographer. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sec.-ft.* | 1906. | | *Feet.* | *Sec.-ft.* |
| June 13 | R. W. Armstrong | 3.45 | 1,256 | June 2[a] | L. J. Bevan | 5.17 | 2,074 |
| June 21 | W. E. Spear | 3.00 | 1,061 | June 2 | do | 5.17 | 2,172 |
| July 1 | do | 2.58 | 869 | June 11 | W. V. Hardy | 5.55 | 2,445 |
| July 10 | R. W. Armstrong | 2.40 | 761 | June 19[a] | L. J. Bevan | 5.73 | 2,382 |
| July 17 | W. E. Spear | 2.32 | 739 | June 19 | do | 5.73 | 2,571 |
| August 10 | do | 2.10 | 668 | June 26[a] | do | 4.82 | 1,924 |
| August 14 | L. J. Bevan | 2.11 | 663 | June 26 | W. V. Hardy | 4.82 | 1,831 |
| August 26 | do | 2.06 | 649 | July 2 | do | 4.26 | 1,517 |
| October 18 | do | 2.01 | 621 | July 3 | L. J. Bevan | 4.21 | 1,607 |
| November 25 | do | 1.96 | 602 | July 9 | do | 3.83 | 1,366 |
| Do | Hawley & Bevan | 1.96 | 601 | July 12 | W. V. Hardy | 3.53 | 1,200 |
| | | | | July 21 | do | 3.05 | 1,016 |
| 1906. | | | | July 24 | L. J. Bevan | 2.93 | 1,023 |
| January 20 | L. J. Bevan | 4.19 | 1,514 | July 31 | W. V. Hardy | 2.75 | 933 |
| January 24 | do | 3.12 | 1,057 | August 3 | L. J. Bevan | 2.71 | 870 |
| February 22 | do | 4.26 | 1,600 | August 4 | W. V. Hardy | 2.65 | 908 |
| March 7 | do | 2.97 | 1,007 | August 16 | do | 2.50 | 826 |
| March 26 | do | 6.50 | 2,852 | August 29 | do | 2.25 | 787 |
| April 11 | do | 5.47 | 2,125 | September 6 | do | 2.15 | 741 |
| May 5 | do | 6.87 | 3,137 | September 19 | L. J. Bevan | 2.25 | 700 |
| May 30 | Hardy & Hawley | 5.80 | 2,539 | October 21 | do | 2.13 | 692 |

[a] 45-pound boiler weight used as anchor for meter.

*Daily gage height, in feet, of North Fork of Feather River below Prattville, Cal., for 1905–6.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905. | | | | | | | | | | | | |
| 1 | | | | | | | 2.59 | | 2.06 | 2.02 | | 2.15 |
| 2 | | | | | | | 2.57 | 2.16 | | 2.01 | | |
| 3 | | | | | | | 2.55 | | 2.04 | 2.00 | | |
| 4 | | | | | | | 2.53 | 2.17 | | | 1.98 | |
| 5 | | | | | | | 2.48 | 2.17 | | 2.00 | 1.98 | 1.85 |
| 6 | | | | | | | 2.50 | 2.16 | | 2.00 | | |
| 7 | | | | | | | 2.49 | 2.17 | 2.04 | 2.04 | | |
| 8 | | | | | | | 2.43 | 2.14 | 2.04 | 2.03 | | |
| 9 | | | | | | | 2.42 | 2.14 | 2.05 | 2.02 | | |
| 10 | | | | | | | 2.42 | 2.09 | 2.03 | | | |
| 11 | | | | | | | 2.39 | 2.11 | 2.03 | 2.01 | | |
| 12 | | | | | | | 2.40 | 2.16 | 2.04 | 2.01 | | 1.83 |
| 13 | | | | | | 3.45 | 2.39 | | 2.04 | 2.01 | | |
| 14 | | | | | | | 2.38 | 2.11 | 2.05 | 2.01 | | 1.93 |
| 15 | | | | | | | 2.39 | 2.11 | 2.04 | 2.01 | | |
| 16 | | | | | | | 2.34 | 2.12 | 2.05 | 2.01 | 1.99 | 2.01 |
| 17 | | | | | | | 2.33 | 2.11 | 2.03 | 2.01 | | |
| 18 | | | | | | 3.17 | | 2.10 | 2.03 | | | |
| 19 | | | | | | 3.05 | 2.32 | 2.10 | 2.03 | | 1.99 | |
| 20 | | | | | | 3.01 | 2.31 | 2.09 | 2.01 | | | |
| 21 | | | | | | 3.01 | 2.32 | 2.11 | 2.01 | | 1.98 | 1.81 |
| 22 | | | | | | 2.90 | 2.28 | 2.14 | 2.00 | | 1.96 | |
| 23 | | | | | | 2.87 | 2.28 | 2.14 | 1.99 | | 1.98 | 1.84 |
| 24 | | | | | | 2.83 | 2.33 | 2.14 | 2.01 | | 1.97 | |
| 25 | | | | | | 2.78 | 2.29 | 2.11 | 2.01 | | 1.97 | 1.91 |
| 26 | | | | | | 2.77 | 2.26 | 2.06 | 2.00 | | | |
| 27 | | | | | | 2.69 | 2.24 | 2.08 | 2.02 | | | |
| 28 | | | | | | 2.66 | 2.22 | 2.07 | 2.16 | | 2.01 | |
| 29 | | | | | | 2.61 | 2.23 | 2.06 | 2.11 | 2.00 | | |
| 30 | | | | | | 2.58 | 2.22 | 2.05 | 2.06 | | | 2.00 |
| 31 | | | | | | | 2.21 | 2.06 | | | | |
| 1906. | | | | | | | | | | | | |
| 1 | | | 3.60 | 5.95 | 5.85 | 5.30 | 4.22 | 2.76 | 2.17 | 2.17 | 2.13 | 1.99 |
| 2 | | | 3.45 | 5.15 | 6.05 | 5.19 | 4.23 | 2.72 | | 2.17 | 2.15 | 2.00 |
| 3 | 1.91 | 2.98 | 3.35 | 4.70 | 6.23 | 5.29 | 4.22 | 2.68 | | 2.16 | 2.25 | 2.01 |
| 4 | | | 3.15 | 4.50 | 6.60 | 5.58 | 4.18 | 2.66 | | 2.16 | 2.62 | 2.01 |
| 5 | | | 3.12 | 4.40 | 6.93 | 6.00 | 4.14 | 2.63 | | 2.16 | 2.88 | 2.02 |
| 6 | 1.93 | 2.91 | 3.05 | 4.45 | 7.10 | 5.92 | 4.04 | 2.63 | | 2.16 | 2.65 | 2.05 |
| 7 | 1.92 | 2.87 | 3.01 | 4.60 | 7.20 | 5.59 | 3.98 | 2.62 | | 2.16 | 2.42 | 2.07 |
| 8 | 1.90 | 2.85 | 3.00 | 4.77 | 7.18 | 5.25 | 3.92 | 2.60 | 2.10 | 2.16 | 2.30 | 2.17 |
| 9 | 1.94 | 2.86 | 3.08 | 5.08 | 7.17 | 5.18 | 3.83 | 2.58 | | 2.15 | 2.24 | 2.25 |
| 10 | 1.94 | 2.90 | 3.24 | 5.46 | 7.27 | 5.37 | 3.73 | 2.56 | | 2.15 | 2.20 | 2.44 |
| 11 | 2.03 | 2.97 | 3.75 | 5.45 | 7.56 | 5.65 | 3.60 | 2.57 | | 2.15 | 2.18 | 2.18 |
| 12 | 2.11 | 3.07 | 4.35 | 5.38 | 7.68 | 5.60 | 3.52 | 2.59 | | 2.15 | 2.17 | 2.10 |
| 13 | 2.15 | 3.11 | | 5.12 | 7.15 | 5.52 | 3.50 | 2.56 | 2.08 | 2.15 | 2.16 | 2.18 |
| 14 | 2.35 | 3.58 | | 5.05 | 6.73 | 5.40 | 3.47 | 2.53 | | | 2.15 | 2.24 |
| 15 | 2.20 | 3.85 | | 5.10 | 6.80 | 5.33 | 3.43 | 2.51 | 2.20 | | 2.16 | 2.29 |
| 16 | 2.80 | 3.79 | | 5.19 | 6.65 | 5.60 | 3.45 | 2.50 | | | 2.24 | 2.35 |
| 17 | 3.12 | 3.68 | 3.60 | 5.36 | 6.05 | 6.28 | 3.28 | 2.47 | | | 2.21 | 2.44 |
| 18 | 4.25 | 4.00 | 3.45 | 5.48 | 6.16 | 6.05 | 3.24 | 2.47 | | | 2.16 | 2.33 |
| 19 | 4.65 | 4.27 | 3.33 | 5.50 | 5.50 | 5.73 | 3.20 | | | | 2.10 | 2.33 |
| 20 | 4.30 | 4.31 | 3.30 | 5.58 | 5.45 | 5.58 | 3.13 | | 2.25 | 2.13 | 2.10 | 2.33 |
| 21 | 3.80 | 4.28 | 3.90 | 5.88 | 5.45 | 5.50 | 3.08 | | 2.22 | 2.13 | 2.11 | 2.31 |
| 22 | 3.54 | 4.15 | 4.65 | 6.18 | 5.40 | 5.40 | 3.01 | | 2.20 | 2.13 | 2.10 | 2.30 |
| 23 | 3.32 | 3.74 | 5.15 | 6.40 | 5.32 | 5.20 | 2.96 | | 2.21 | 2.13 | 2.02 | 2.38 |
| 24 | 3.28 | 3.70 | 5.85 | 6.35 | 5.18 | 5.02 | 2.94 | | 2.23 | 2.13 | 2.04 | 2.48 |
| 25 | 3.13 | 3.62 | 6.30 | 6.00 | 5.27 | 4.86 | 2.90 | 2.25 | 2.22 | 2.13 | 2.05 | 3.42 |
| 26 | 3.17 | 3.45 | 6.47 | 5.65 | 5.90 | 4.80 | 2.87 | | 2.20 | 2.12 | 2.04 | 4.40 |
| 27 | 3.32 | 3.65 | 5.90 | 5.50 | 6.36 | 4.68 | 2.84 | | 2.19 | 2.11 | 2.02 | 4.57 |
| 28 | | 3.80 | 5.25 | 5.60 | 6.33 | 4.52 | 2.83 | | 2.19 | 2.11 | 2.01 | 4.65 |
| 29 | | | 4.80 | 5.55 | 6.17 | 4.35 | 2.80 | | 2.18 | 2.10 | 1.97 | 4.35 |
| 30 | | | 5.15 | 5.69 | 5.78 | 4.25 | 2.78 | | 2.17 | 2.10 | 2.01 | 3.95 |
| 31 | | | 6.35 | | 5.48 | | 2.76 | | | 2.13 | | 3.60 |

*Rating table for North Fork of Feather River below Prattville, Cal., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.80 | 570 | 2.50 | 805 | 3.20 | 1,090 | 3.90 | 1,410 | 4.60 | 1,770 |
| 1.90 | 600 | 2.60 | 845 | 3.30 | 1,135 | 4.00 | 1,460 | 4.70 | 1,825 |
| 2.00 | 630 | 2.70 | 885 | 3.40 | 1,180 | 4.10 | 1,510 | 4.80 | 1,880 |
| 2.10 | 665 | 2.80 | 925 | 3.50 | 1,225 | 4.20 | 1,560 | 4.90 | 1,935 |
| 2.20 | 700 | 2.90 | 965 | 3.60 | 1,270 | 4.30 | 1,610 | 5.00 | 1,990 |
| 2.30 | 735 | 3.00 | 1,005 | 3.70 | 1,315 | 4.40 | 1,660 | 5.10 | 2,045 |
| 2.40 | 770 | 3.10 | 1,045 | 3.80 | 1,360 | 4.50 | 1,715 | 5.20 | 2,100 |

NOTE.—This table is based on 40 discharge measurements made during 1905–6 and is well defined. Above gage height 5.2 feet the rating curve is a tangent, the difference being 60 per tenth.

*Monthly discharge of North Fork of Feather River below Prattville, Cal., for 1905–6.*

[Drainage area, 506 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| July | 845 | 700 | 761 | 46,800 | 1.50 | 1.73 |
| August | 700 | 647 | 670 | 42,000 | 1.32 | 1.52 |
| September | 682 | 630 | 644 | 38,300 | 1.27 | 1.46 |
| October | 647 | 630 | 631 | 38,800 | 1.25 | 1.44 |
| November | 630 | 615 | 628 | 37,400 | 1.24 | 1.43 |
| December | 682 | 570 | 607 | 37,300 | 1.20 | 1.38 |
| The period | 845 | 570 | 657 | 241,000 | 1.30 | 8.96 |
| 1906. | | | | | | |
| January | 1,800 | 600 | 937 | 57,600 | 1.85 | 2.13 |
| February | 1,610 | 945 | 1,210 | 67,200 | 2.39 | 2.49 |
| March | 2,850 | 1,000 | 1,590 | 97,800 | 3.14 | 3.62 |
| April | 2,820 | 1,660 | 2,210 | 132,000 | 4.37 | 4.88 |
| May | 3,600 | 2,100 | 2,770 | 170,000 | 5.47 | 6.31 |
| June | 2,760 | 1,580 | 2,190 | 130,000 | 4.33 | 4.83 |
| July | 1,580 | 905 | 1,200 | 73,800 | 2.37 | 2.73 |
| August | 905 | 700 | 795 | 48,900 | 1.57 | 1.81 |
| September | 717 | 665 | 688 | 40,900 | 1.36 | 1.52 |
| October | 682 | 665 | 679 | 41,800 | 1.34 | 1.54 |
| November | 965 | 615 | 698 | 41,500 | 1.38 | 1.54 |
| December | 1,800 | 630 | 894 | 55,000 | 1.77 | 2.04 |
| The year | 3,600 | 600 | 1,320 | 956,000 | 2.61 | 35.44 |

NOTE.—Discharge estimated on days when gage heights are missing. Values are excellent.

## NORTH FORK OF FEATHER RIVER ABOVE PRATTVILLE.

This station was established June 12, 1905. It is 3 miles east of Prattville and about $\frac{1}{4}$ mile above the junction with Hamilton Branch. The drainage area above the station is 245 square miles.

The channel of the stream is straight for 200 feet above and 300 feet below the measuring section and has a shale bottom subject to slight change. Gagings are made from a boat. The section is about 65 feet wide and 5 feet deep at low water; at very high water there is a diversion overflow around the station, leaving the main stream about $1\frac{1}{2}$ miles above the point of measurement.

The gage is nailed to a willow stump 15 feet above the measuring section. Up to October 15, during 1905, the gage was read daily; after this date, weekly.

*Discharge measurements of North Fork of Feather River above Prattville, Cal., in 1905–6.*

| Date. | Hydrographer. | Gage height. | Discharge. |
|---|---|---|---|
| 1905. | | *Feet.* | *Sec.-ft.* |
| June 12 | R. W. Armstrong | 2.33 | 890 |
| June 22 | W. E. Spear | 1.79 | 620 |
| July 1 | do | 1.48 | 520 |
| July 15 | R. W. Armstrong | 1.23 | 407 |
| July 28 | W. E. Spear | 1.09 | 399 |
| August 15 | L. J. Bevan | .99 | 370 |
| September 4 | do | .90 | 345 |
| December 17 | do | .80 | 330 |
| 1906. | | | |
| February 28 | L. J. Bevan | 1.82 | 669 |
| April 12 | do | 2.77 | 1,046 |
| May 15 | do | 3.83 | 1,524 |
| July 7 | do | 2.48 | 929 |
| August 8 | do | 1.34 | 502 |

*Daily gage height, in feet, of North Fork of Feather River above Prattville, Cal., for 1905–6.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905. | | | | | | | | | | | | |
| 1 | | | | | | | 1.50 | 1.05 | 0.90 | 0.88 | | |
| 2 | | | | | | | 1.48 | 1.06 | .91 | .85 | | |
| 3 | | | | | | | 1.47 | | .90 | .84 | | |
| 4 | | | | | | | 1.46 | 1.05 | .90 | .84 | 0.82 | |
| 5 | | | | | | | 1.39 | 1.05 | .90 | .85 | | |
| 6 | | | | | | | 1.40 | 1.04 | | .85 | | |
| 7 | | | | | | | 1.35 | 1.02 | .88 | .90 | | |
| 8 | | | | | | | 1.33 | 1.01 | .87 | .90 | | |
| 9 | | | | | | | 1.32 | 1.02 | .90 | .88 | | |
| 10 | | | | | | | 1.31 | 1.01 | .90 | | | |
| 11 | | | | | | | 1.29 | 1.00 | .87 | .87 | | |
| 12 | | | | | | | 1.27 | 0.99 | .86 | .87 | | 0.75 |
| 13 | | | | | | | 1.26 | .99 | .86 | .86 | | |
| 14 | | | | | | | 1.24 | .99 | .89 | .86 | | |
| 15 | | | | | | | 1.23 | .99 | .89 | .87 | | |
| 16 | | | | | | | 1.22 | .97 | .90 | .86 | 0.83 | |
| 17 | | | | | | 2.08 | 1.20 | .95 | .88 | | | 0.80 |
| 18 | | | | | | | | .95 | .87 | | | |
| 19 | | | | | | 1.97 | 1.18 | .94 | .86 | | 0.82 | |
| 20 | | | | | | 1.90 | 1.18 | .94 | .85 | | | |
| 21 | | | | | | 1.86 | 1.16 | .95 | .84 | | | 0.81 |
| 22 | | | | | | 1.80 | 1.15 | .97 | .82 | | | |
| 23 | | | | | | 1.78 | 1.14 | .96 | .82 | | | |
| 24 | | | | | | 1.76 | 1.16 | .98 | .84 | | | |
| 25 | | | | | | 1.69 | 1.15 | .95 | .85 | | | |
| 26 | | | | | | 1.67 | 1.14 | .90 | .84 | | | |
| 27 | | | | | | 1.59 | 1.14 | .94 | .87 | | | |
| 28 | | | | | | 1.55 | 1.09 | .92 | .90 | | 0.87 | |
| 29 | | | | | | 1.53 | 1.10 | .91 | .95 | 0.85 | | |
| 30 | | | | | | 1.51 | 1.07 | .90 | .90 | | | 0.87 |
| 31 | | | | | | | 1.06 | .90 | | | | |
| 1906. | | | | | | | | | | | | |
| 1 | | | | | | | | | 1.12 | | | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | 2.83 | | | | | 1.00 | |
| 4 | | | | | | | | 1.40 | | | | |
| 5 | | | | | 3.92 | | | | | | | |
| 6 | 0.76 | 1.19 | | | | | | | | | | |
| 7 | | | | 2.51 | | | 2.48 | | | 0.90 | | |
| 8 | | | | | | | | 1.34 | 1.04 | | | 0.94 |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |
| 11 | | | | | | | | 1.34 | | | 0.95 | |
| 12 | | | | | 4.15 | | | | | | | |
| 13 | 0.88 | | | | | | | | | | | |
| 14 | | | | 2.60 | | | 2.06 | | | 0.89 | | |
| 15 | | | | | 3.83 | | | | 1.06 | | | 0.95 |

*Daily gage height, in feet, of North Fork of Feather River above Prattville, Cal., for 1905–6—* Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | | | | | | | | | | | | |
| 16 | | | | | | 3.30 | | | | | | |
| 17 | | 1.55 | 1.55 | | | | | | | | 0.98 | |
| 18 | | | | | | | | 1.20 | | | | |
| 19 | 1.68 | | | | 2.90 | | | | | | | |
| 20 | | | | | | | | | 0.96 | | | |
| 21 | | | | | | | 1.80 | | | 0.88 | | |
| 22 | | | | | | | | | 0.96 | | | 3.97 |
| 23 | | | | | | 3.32 | | | | | | |
| 24 | | 1.55 | 2.59 | | | | | | | | 0.96 | |
| 25 | | | | | | | | 1.18 | | | | |
| 26 | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | |
| 28 | | 1.82 | | | | | 1.48 | | | 0.86 | | |
| 29 | | | | | 3.18 | | | | 0.94 | | | 2.54 |
| 30 | | | | | | 2.57 | | | | | | |
| 31 | | | 2.04 | | | | | | | | | |

## HAMILTON BRANCH NEAR PRATTVILLE, CAL.

This station was established June 12, 1905. It is located about 3 miles east of Prattville and 1¼ miles above the junction of Hamilton Branch and North Fork. The drainage area above the station is 230 square miles.

The channel is straight for 200 feet above and below the measuring section and has a shale bottom subject to a very slight change.

Discharge measurements are made from a boat at a section about 70 feet wide and 4 feet deep at low water. The stream never overflows.

The gage is in two parts, nailed to posts driven into the stream bed near a clump of willows. Up to October 15, during 1905, the gage was read daily; after that date, weekly.

*Discharge measurements of Hamilton Branch near Prattville, Cal., in 1905–6.*

| Date. | Hydrographer. | Gage height. | Discharge. |
|---|---|---|---|
| 1905. | | *Feet.* | *Sec.-ft.* |
| June 12 | R. W. Armstrong | 3.08 | 394 |
| June 23 | W. E. Spear | 2.74 | 243 |
| July 3 | do | 2.62 | 215 |
| July 28 | do | 2.56 | 209 |
| August 15 | L. J. Bevan | 2.56 | 211 |
| September 4 | do | 2.55 | 210 |
| December 17 | do | 2.40 | 177 |
| 1906. | | | |
| January 19 | L. J. Bevan | 3.60 | 567 |
| February 28 | do | 3.92 | 745 |
| April 12 | do | 4.43 | 1,017 |
| May 15 | do | 5.21 | 1,494 |
| July 7 | do | 3.19 | 439 |
| August 8 | do | 2.77 | 334 |

*Daily gage height, in feet, of Hamilton Branch near Prattville, Cal., for 1905–6.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905. | | | | | | | | | | | | |
| 1 | | | | | | | 2.66 | 2.56 | 2.55 | 2.54 | | |
| 2 | | | | | | | 2.64 | 2.56 | 2.55 | 2.53 | | |
| 3 | | | | | | | 2.64 | | 2.55 | 2.53 | | |
| 4 | | | | | | | 2.63 | 2.56 | 2.55 | 2.50 | 2.47 | |
| 5 | | | | | | | 2.62 | 2.55 | 2.55 | 2.48 | | |
| 6 | | | | | | | 2.63 | 2.56 | | 2.48 | | |
| 7 | | | | | | | 2.61 | 2.56 | 2.54 | 2.50 | | |
| 8 | | | | | | | 2.60 | 2.55 | 2.54 | 2.50 | | |
| 9 | | | | | | | 2.59 | 2.56 | 2.54 | 2.50 | | |
| 10 | | | | | | | 2.59 | 2.56 | 2.54 | | | |
| 11 | | | | | | | 2.58 | 2.55 | 2.53 | 2.49 | | |
| 12 | | | | | | | 2.58 | 2.56 | 2.53 | 2.49 | | 2.40 |
| 13 | | | | | | | 2.58 | 2.56 | 2.53 | 2.49 | | |
| 14 | | | | | | | 2.57 | 2.55 | 2.53 | 2.48 | | |
| 15 | | | | | | | 2.57 | 2.56 | 2.53 | 2.49 | | |
| 16 | | | | | | | 2.58 | 2.57 | 2.53 | 2.48 | 2.46 | |
| 17 | | | | | | 2.91 | 2.58 | 2.56 | 2.53 | | | 2.40 |
| 18 | | | | | | | | 2.57 | 2.53 | | | |
| 19 | | | | | | 2.84 | 2.58 | 2.58 | 2.53 | | | |
| 20 | | | | | | 2.82 | 2.58 | 2.57 | 2.52 | | 2.45 | |
| 21 | | | | | | 2.80 | 2.60 | 2.58 | 2.52 | | | 2.40 |
| 22 | | | | | | 2.76 | 2.58 | 2.59 | 2.52 | | | |
| 23 | | | | | | 2.74 | 2.59 | 2.58 | 2.52 | | | |
| 24 | | | | | | 2.72 | 2.62 | 2.58 | 2.52 | | | |
| 25 | | | | | | 2.70 | 2.61 | 2.56 | 2.52 | | | |
| 26 | | | | | | 2.70 | 2.60 | 2.56 | 2.52 | | | |
| 27 | | | | | | 2.67 | 2.60 | 2.57 | 2.50 | | | |
| 28 | | | | | | 2.67 | 2.57 | 2.56 | 2.54 | | 2.44 | |
| 29 | | | | | | 2.65 | 2.56 | 2.55 | 2.54 | 2.48 | | |
| 30 | | | | | | 2.62 | 2.56 | 2.55 | 2.52 | | | 2.44 |
| 31 | | | | | | | 2.56 | 2.56 | | | | |
| 1906. | | | | | | | | | | | | |
| 1 | | | | | | | 3.42 | | 2.68 | | | |
| 2 | | | | | 4.62 | 4.22 | | | | | | |
| 3 | | | | | | | | | | | 2.62 | |
| 4 | | | | | | | | 2.75 | | | | |
| 5 | | | | | 5.17 | | | | | | | |
| 6 | 2.39 | 3.22 | | | | | | | | | | |
| 7 | | | | 3.87 | | | 3.20 | | | 2.58 | | |
| 8 | | | | | | | | 2.77 | 2.65 | | | 2.59 |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |
| 11 | | | | | | | | 2.76 | | | 2.57 | |
| 12 | | | | | 5.75 | | | | | | | |
| 13 | | | | | | | | | | | | |
| 14 | | | | 4.30 | | | 3.00 | | | 2.57 | | |
| 15 | | | | | 5.21 | | | | 2.69 | | | 2.60 |
| 16 | 2.81 | | | | | 4.18 | | | | | | |
| 17 | | 3.71 | 3.57 | | | | | | | | 2.60 | |
| 18 | | | | | | | | 2.71 | | | | |
| 19 | 3.60 | | | | 4.45 | | | | | | | |
| 20 | | | | | | | | | 2.61 | | | |
| 21 | | | | | | | 2.85 | | | 2.58 | | |
| 22 | | | | | | | | | 2.60 | | | 2.72 |
| 23 | | | | | | 4.00 | | | | | | |
| 24 | | 3.93 | 4.88 | | | | | | | | 2.60 | |
| 25 | | | | | | | | 2.68 | | | | |
| 26 | | | | | | | | | | | | |
| 27 | | | | | | | | | | 2.51 | | |
| 28 | | 3.92 | | | | | 2.78 | | | | | |
| 29 | | | | | 4.95 | | | | 2.59 | | | 4.13 |
| 30 | | | | | | 3.50 | | | | | | |
| 31 | | | 5.18 | | | | | | | | | |

## BUTT CREEK AT BUTTE VALLEY, CAL.

Butt Creek rises in the extreme western part of Plumas County and flows eastward, discharging into North Fork of Feather River about 9 miles south of Prattville.

This station was established June 14, 1905, about 2 miles above the mouth of the river, and 100 feet below the footbridge at the lower end of Butte Valley. The drainage area above the station is 73 square miles.

The measuring section is 20 feet wide and 2 feet deep at low water, when measurements are made by wading; in high stages measurements are made from the footbridge. The bottom of the channel is composed of coarse gravel and is not subject to much change.

The gage rod is nailed to a post in a clump of willows 15 feet below the measuring section. During 1905 and until July, 1906, the gage was read daily by B. F. Barbee. Since July, 1906, W. W. Savercool has made readings whenever there was any material change of stage.

*Discharge measurements of Butt Creek at Butte Valley, Cal., in 1905–6.*

| Date. | Hydrographer. | Gage height. | Discharge. |
|---|---|---|---|
| 1905. | | *Feet.* | *Sec.-ft.* |
| June 14 | R. W. Armstrong | 2.84 | 76 |
| July 18 | do | 2.51 | 42 |
| August 19 | do | 2.39 | 35 |
| September 9 | W. E. Spear | 2.38 | 30 |
| 1906. | | | |
| March 2 | L. J. Bevan | 3.16 | 136 |
| March 27 | do | 4.54 | 365 |
| April 10 | do | 4.75 | 426 |
| June 21 | do | 3.54 | 179 |
| July 24 | do | 2.68 | 57 |
| August 30 | W. V. Hardy | | 42 |

NOTE.—About 5 second-feet are diverted 6 miles above this station from Butt Creek into Yellow Creek watershed.

*Daily gage height, in feet, of Butt Creek at Butte Valley, Cal., for 1905–6.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905. | | | | | | | | | | | | |
| 1 | | | | | | | | | | | 2.38 | 2.55 |
| 2 | | | | | | | | | | | 2.38 | 2.63 |
| 3 | | | | | | | | | | | 2.38 | 2.63 |
| 4 | | | | | | | | | | | 2.38 | 2.61 |
| 5 | | | | | | | | | | | 2.38 | 2.65 |
| 6 | | | | | | | | | | 2.38 | 2.38 | 2.65 |
| 7 | | | | | | | | | | 2.38 | 2.38 | 2.64 |
| 8 | | | | | | | | | | | 2.38 | 2.63 |
| 9 | | | | | | | | | 2.38 | 2.37 | 2.38 | 2.65 |
| 10 | | | | | | | | | | 2.37 | 2.38 | 2.74 |
| 11 | | | | | | | | | | 2.38 | 2.38 | 2.77 |
| 12 | | | | | | | | | | 2.38 | 2.38 | 2.60 |
| 13 | | | | | | | | | | 2.38 | 2.38 | 2.76 |
| 14 | | | | | | 2.84 | | | | 2.38 | 2.38 | 2.77 |
| 15 | | | | | | | | | | 2.38 | 2.38 | 2.77 |
| 16 | | | | | | | | | | 2.38 | 2.38 | 2.72 |
| 17 | | | | | | | | | | 2.38 | 2.38 | 2.59 |
| 18 | | | | | | | 2.51 | | | 2.38 | 2.38 | 2.51 |
| 19 | | | | | | | | 2.39 | | 2.38 | 2.38 | 2.51 |
| 20 | | | | | | | | | | 2.38 | 2.45 | 2.59 |

*Daily gage height, in feet, of Butt Creek at Butte Valley, Cal., for 1905 6* Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905. | | | | | | | | | | | | |
| 21 | | | | | | | | | | 2.38 | 2.42 | 2.76 |
| 22 | | | | | | | | | | 2.38 | 2.42 | 2.76 |
| 23 | | | | | | | | | | 2.38 | 2.44 | 2.73 |
| 24 | | | | | | | | | | 2.38 | 2.43 | 2.73 |
| 25 | | | | | | | | | | 2.38 | 2.43 | 2.73 |
| 26 | | | | | | | | | | 2.38 | 2.43 | 2.76 |
| 27 | | | | | | | | | | 2.38 | 2.44 | 2.71 |
| 28 | | | | | | | | | | 2.38 | 2.43 | 2.68 |
| 29 | | | | | | | | | | 2.38 | 2.43 | 2.68 |
| 30 | | | | | | | | | | 2.38 | 2.45 | 2.67 |
| 31 | | | | | | | | | | 2.38 | | 2.78 |
| 1906. | | | | | | | | | | | | |
| 1 | 2.85 | 2.70 | 3.42 | 5.15 | 4.30 | 3.94 | 3.06 | 2.61 | 2.57 | | | |
| 2 | 2.88 | 2.68 | 3.31 | 4.50 | 4.33 | 3.99 | 3.13 | 2.61 | | | | |
| 3 | 2.91 | 2.68 | 3.28 | 4.17 | 4.53 | 4.02 | 3.02 | 2.61 | | | | |
| 4 | 2.94 | 2.68 | 3.25 | 4.02 | 4.65 | 4.42 | 2.98 | 2.60 | | | | |
| 5 | 2.96 | 2.69 | 3.17 | 3.96 | 4.80 | 4.20 | 2.93 | 2.59 | | | 2.93 | |
| 6 | 2.99 | 2.69 | 3.15 | 4.06 | 4.72 | 4.22 | 2.90 | 2.59 | | 2.54 | | |
| 7 | 3.03 | 2.69 | 3.16 | 4.30 | 4.78 | 4.24 | 2.89 | 2.59 | | | 2.65 | |
| 8 | 3.03 | 2.71 | 3.24 | 4.38 | 4.70 | 3.87 | 2.87 | 2.59 | 2.57 | | | 2.43 |
| 9 | 3.07 | 2.71 | 3.34 | 4.70 | 4.72 | 3.83 | 2.83 | 2.59 | | | | |
| 10 | 3.10 | 2.94 | 3.46 | 4.72 | 4.76 | 3.83 | 2.81 | 2.58 | | | 2.61 | 2.63 |
| 11 | 2.76 | 2.95 | 3.73 | 4.35 | 4.65 | 3.79 | 2.79 | 2.60 | | | | 2.67 |
| 12 | 2.83 | 2.95 | 3.75 | 4.45 | 4.48 | 3.92 | 2.77 | 2.61 | | | | 3.13 |
| 13 | 2.85 | 2.97 | 3.15 | 4.42 | 4.33 | 3.75 | 2.80 | 2.61 | 2.63 | 2.55 | | 3.13 |
| 14 | 2.93 | 3.25 | 4.30 | 4.41 | 4.34 | 3.68 | 2.78 | 2.61 | 2.61 | | | 3.13 |
| 15 | 2.98 | 3.65 | 4.02 | 4.58 | 4.37 | 3.65 | 2.77 | | 2.62 | | | 3.10 |
| 16 | 4.66 | 3.30 | 3.78 | 4.70 | 4.00 | 4.18 | 2.75 | | | | | 3.10 |
| 17 | 5.14 | 3.24 | 3.47 | 4.57 | 3.83 | 3.87 | 2.74 | | | | 2.58 | 3.11 |
| 18 | 7.69 | 3.60 | 3.35 | 4.53 | 3.70 | 3.71 | 2.74 | | | | | 2.68 |
| 19 | 6.72 | 4.09 | 3.27 | 4.56 | 3.72 | 3.64 | 2.72 | | | | | 2.63 |
| 20 | 5.45 | 3.75 | 3.27 | 4.73 | 3.70 | 3.39 | 2.72 | | | 2.55 | | 2.63 |
| 21 | 5.15 | 3.95 | 3.42 | 4.88 | 3.71 | 3.55 | 2.71 | | | | | 2.61 |
| 22 | 5.53 | 3.65 | 4.22 | 4.87 | 3.68 | 3.47 | 2.71 | | 2.59 | | | 2.60 |
| 23 | 3.16 | 3.55 | 4.40 | 4.63 | 3.67 | 3.40 | 2.69 | | | | | 2.67 |
| 24 | 3.00 | 3.42 | 4.90 | 4.43 | 3.68 | 3.33 | 2.69 | | | | | 2.72 |
| 25 | 2.90 | 3.35 | 4.90 | 4.25 | 3.84 | 3.30 | 2.68 | 2.60 | | | | 3.28 |
| 26 | 2.82 | 3.30 | 4.56 | 4.13 | 4.55 | 3.27 | 2.68 | | | | | 4.43 |
| 27 | 2.81 | 4.09 | 5.54 | 4.12 | 4.50 | 3.22 | 2.67 | | | 2.55 | | 4.33 |
| 28 | 2.75 | 4.10 | 4.20 | 4.22 | 4.38 | 3.21 | 2.66 | | | | | 3.42 |
| 29 | 2.72 | | 4.10 | 4.20 | 4.20 | 3.12 | 2.64 | | 2.56 | | 2.45 | 3.10 |
| 30 | 2.70 | | 5.00 | 4.28 | 4.10 | 3.09 | 2.62 | | | | | |
| 31 | 2.70 | | 6.00 | | 3.97 | | 2.61 | | | | | |

## NORTH FORK OF FEATHER RIVER NEAR BIG BEND, CAL.

This station was established June 13, 1905. It is located 300 feet above the head of the Big Bend tunnel, about 20 miles north of Oroville. The drainage area at this point is 1,940 square miles.

The channel is straight for 500 feet above and below the station, and is in rock, with little probability of change. A low-water gage graduated from 0.0 to 7.5 feet is bolted into rock on the west bank 10 feet below the measuring section, and a high-water gage graduated from 7 to 22 feet is nailed to a poplar tree on the west bank 100 feet above the measuring section. The zero of the gage is 870.22 feet above sea level and 7.89 feet below the reference bench mark, which is a knob on the top of the rock to which the low-water gage is fastened.

Discharge measurements are made by means of a boat when the gage is below 11 feet, and for higher stages float measurements only

are made at this point, while check measurements are made 2 miles downstream from the cable of the Golden State Power Company. At low water the stream at the station is about 85 feet wide and 19 feet deep, with a uniform but sluggish current. During 1905 and 1906 the gage was read every other day by Henry Turner.

*Discharge measurements of North Fork of Feather River near Big Bend, Cal., by Spear and Bevan, in 1905–6.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | *Feet.* | *Sec.-ft.* | 1906. | *Feet.* | *Sec.-ft.* |
| June 13 | 4.15 | 3,750 | March 13 | 12.25 | 13,230 |
| July 13 | 2.75 | 1,352 | April 18 | 10.24 | 9,962 |
| August 20 | 2.14 | 1,048 | April 28 | 8.98 | 8,052 |
| September 16 | 2.07 | 1,003 | June 6 | 9.55 | 8,655 |
| October 22 | 2.15 | 1,038 | June 7 | 9.08 | 8,332 |
| December 5 | 2.25 | 1,101 | July 13 | 4.73 | 3,081 |
| 1906. | | | August 12 | 3.03 | 1,677 |
| February 2 | 4.79 | 3,017 | October 11 | 2.44 | 1,269 |

*Daily gage height, in feet, of North Fork of Feather River near Big Bend, Cal., for 1905–6.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905. | | | | | | | | | | | | |
| 1 | | | | | | | | | | | 2.17 | 2.32 |
| 2 | | | | | | | | 2.26 | 2.06 | 2.18 | | |
| 3 | | | | | | | | | | 2.15 | 2.17 | 2.27 |
| 4 | | | | | | | | 2.06 | 2.06 | 2.10 | | 2.31 |
| 5 | | | | | | | | | | 2.08 | 2.17 | 2.25 |
| 6 | | | | | | | | 2.24 | 2.07 | | | 2.27 |
| 7 | | | | | | | | | | 2.10 | 2.18 | 2.25 |
| 8 | | | | | | | | 2.21 | 2.06 | | | |
| 9 | | | | | | | | | 2.06 | 2.12 | | 2.21 |
| 10 | | | | | | | | 2.17 | | | | |
| 11 | | | | | | | | | 2.05 | 2.11 | 2.17 | 2.11 |
| 12 | | | | | | | | 2.16 | | | | |
| 13 | | | | | | | 2.75 | 2.16 | 2.05 | 2.13 | 2.18 | 2.18 |
| 14 | | | | | | | | | | | | 2.22 |
| 15 | | | | | | | 2.66 | 2.17 | 2.08 | 2.12 | 2.17 | |
| 16 | | | | | | | | | 2.07 | | | 2.26 |
| 17 | | | | | | | 2.62 | 2.15 | | 2.11 | 2.18 | 2.27 |
| 18 | | | | | | | | | 2.06 | | | |
| 19 | | | | | | | 2.60 | 2.13 | | 2.10 | 2.18 | 2.66 |
| 20 | | | | | | | | 2.10 | 2.06 | 2.12 | | |
| 21 | | | | | | | 2.55 | 2.13 | | | 2.27 | 2.44 |
| 22 | | | | | | | | | | 2.15 | 2.37 | 2.36 |
| 23 | | | | | | | 2.50 | 2.20 | | | 2.19 | |
| 24 | | | | | | | | | | | | 2.24 |
| 25 | | | | | | | 2.46 | 2.14 | 2.05 | 2.18 | 2.18 | |
| 26 | | | | | | | | 2.11 | | | | 2.29 |
| 27 | | | | | | | 2.35 | | 2.07 | 2.20 | 2.57 | 2.36 |
| 28 | | | | | | | | 2.07 | | | | |
| 29 | | | | | | | 2.34 | | 2.35 | 2.19 | 2.37 | 2.26 |
| 30 | | | | | | | | 2.06 | 2.25 | 2.18 | | |
| 31 | | | | | | | 2.28 | | | | | |
| 1906. | | | | | | | | | | | | |
| 1 | 2.24 | | | | | 10.65 | | 3.25 | 2.62 | | | 2.45 |
| 2 | | 4.80 | 7.65 | 11.80 | 9.85 | 8.95 | 6.25 | 3.20 | | | 2.40 | |
| 3 | 2.24 | | | | | | | | 2.58 | | 3.02 | 2.50 |
| 4 | | 4.65 | 7.30 | 9.55 | 10.60 | | 6.23 | 3.12 | 2.58 | | 5.90 | |
| 5 | 2.30 | | | | | 11.20 | | | | | 4.60 | 2.50 |
| 6 | 2.31 | 4.54 | 6.58 | 8.76 | 11.20 | 9.55 | 5.85 | 3.08 | 2.58 | | | |
| 7 | | | 6.50 | | | 9.15 | | | 2.58 | | 3.40 | 2.50 |
| 8 | 2.35 | 4.50 | | 9.60 | 11.25 | | 5.50 | 3.00 | | | | |
| 9 | | | 6.46 | | | 9.05 | | | 2.55 | | 3.00 | 3.20 |
| 10 | 2.30 | 4.65 | | 10.70 | 11.85 | | 5.25 | 2.97 | 2.53 | | | |

*Daily gage height, in feet, of North Fork of Feather River near Big Bend, Cal., for 1905–6*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906. | | | | | | | | | | | | |
| 11 | | | 7.35 | | | 9.00 | | | | 2.44 | 2.80 | 6.20 |
| 12 | 2.96 | 4.79 | 13.45 | 9.85 | 11.20 | | 4.85 | 3.03 | 2.52 | | | |
| 13 | | 4.81 | 12.25 | | | 8.90 | 4.73 | 3.01 | | | 2.75 | 5.10 |
| 14 | 2.46 | | 10.06 | 9.75 | 10.05 | 8.75 | 4.60 | | 2.60 | 2.44 | | |
| 15 | | 8.15 | 8.85 | | | | | 2.90 | | | 2.75 | 3.10 |
| 16 | 13.23 | | | 10.30 | 9.40 | 9.30 | 4.38 | | 2.58 | | | |
| 17 | | 6.51 | 7.85 | | | | | | | | 2.83 | 3.80 |
| 18 | 18.48 | | | 10.25 | 8.85 | 8.85 | 4.22 | 2.85 | 2.58 | | | |
| 19 | 19.90 | 7.75 | 6.74 | 10.22 | | | | | 2.56 | | 2.73 | 3.60 |
| 20 | 12.22 | 8.20 | | | 8.40 | 8.40 | 3.90 | 2.78 | 2.55 | | | |
| 21 | | | 7.54 | 10.85 | | | | | 2.53 | | 2.67 | 3.50 |
| 22 | 7.15 | 8.97 | 10.35 | | 8.00 | 7.90 | 3.68 | | | | | |
| 23 | | | | 11.10 | | | | 2.75 | | | 2.65 | 3.80 |
| 24 | 5.88 | 8.10 | 14.00 | | 7.50 | 7.30 | 3.60 | 2.73 | | | | |
| 25 | | | | 10.65 | | | | | | | 2.60 | 8.80 |
| 26 | 5.56 | 8.75 | 14.70 | | 7.90 | 6.95 | 3.53 | 2.66 | | | | 15.40 |
| 27 | | | | 9.35 | 8.40 | | | | | | 2.55 | 13.00 |
| 28 | 5.25 | 9.80 | 12.10 | 9.00 | 11.05 | 6.68 | 3.45 | | | | | 9.55 |
| 29 | | | | | 10.45 | | | | | 2.40 | 2.50 | |
| 30 | 5.10 | | 12.34 | 8.40 | | 6.39 | 3.35 | 2.65 | | | | |
| 31 | 4.88 | | | | 9.35 | | | | | | | |

## MISCELLANEOUS MEASUREMENTS IN FEATHER RIVER DRAINAGE BASIN.

The following miscellaneous measurements were made in Feather River drainage basin during 1905 and 1906:

*Bailey Creek near Prattville, Cal.*—This stream is a tributary of North Fork of Feather River. The following measurements were made a short distance above its mouth.

1905—July 31: Discharge, 2.6 second-feet.
1906—May 23: Discharge, 50 second-feet.
September 5: Discharge, 3.3 second-feet.

*Berry Creek near Berrycreek post-office, Cal.*—This creek is a small tributary of the North Fork of Feather River. A measurement was made September 11, 1906, at wagon bridge at Berrycreek post-office:

Width, 20 feet; area, 27 square feet; discharge, 8 second-feet.

*Big Springs near Prattville, Cal.*—These springs discharge into Hamilton Branch of North Fork of Feather River. The following measurements were made above its mouth:

1905—June 13: Discharge, 56 second-feet.
July 5: Discharge, 65 second-feet.
August 8: Discharge, 69 second-feet.
September 1: Discharge, 50 second-feet.
December 16: Discharge, 61 second-feet.
1906—June 1: Discharge, 150 second-feet.
July 6: Discharge, 56 second-feet.
August 7: Discharge, 61 second-feet.

*Butt Creek near Prattville, Cal.*—This stream is a tributary of North Fork of Feather River. The following measurements were made at the bridge on Prattville-Sterling road:

1905—July 11: Discharge, 21 second-feet.
1906—March 27: Discharge, 156 second-feet.
June 21: Discharge, 142 second-feet.
July 20: Discharge 54 second-feet.

*Clear Creek near Prattville, Cal.*—This stream is a tributary of Hamilton Branch of North Fork of Feather River. The following measurements were made in 1905 a short distance above its mouth:

July 5: Discharge, 29 second-feet.
August 8: Discharge, 28 second-feet.
September 1: Discharge, 27 second-feet.

*Chester Branch of North Fork of Feather River near Prattville, Cal.*—The following measurements were made at the wagon bridge at Chester, Cal.:

1905—July 7: Discharge, 35 second-feet.
August 5: Discharge, 23 second-feet.
August 31: Discharge, 21 second-feet.
October 4: Discharge, 23 second-feet.
1906—March 1: Discharge, 48 second-feet.
June 23: Discharge, 95 second-feet.
July 11: Discharge, 70 second-feet.
September 5: Discharge, 45 second-feet.

*Dotta Spring near Prattville, Cal.*—This spring discharges into North Fork Feather River. The following measurements were made 400 feet above its mouth.

1905—June 12: Discharge, 50 second-feet.
July 3: Discharge, 99 second-feet.
August 5: Discharge, 84 second-feet.
September 2: Discharge, 89 second-feet.
October 18: Discharge, 90 second-feet.
December 14: Discharge, 77 second-feet.
1906—June 21: Discharge, 122 second-feet.
August 3: Discharge, 94 second-feet.

*Feather River near Bidwell Bar.*—The following measurements were made 2 miles below Bidwell Bar and above the junction with North Fork of Feather River during 1905:

June 11: Discharge, 1,525 second-feet.
July 25: Discharge, 410 second-feet.
August 19: Discharge, 279 second-feet.
September 17: Discharge, 256 second-feet.

*Flournoy ditch near Genesee, Cal.*—This ditch diverts water from Red Clover Creek for irrigation at Flournoy's ranch. A measurement was made August 21, 1906, 1¼ miles southeast of Flournoy, a short distance below the point of diversion:

Width, 4 feet; area, 3.6 square feet; discharge, 9.5 second-feet.

*Hamilton Branch of North Fork of Feather River near Prattville, Cal.*—The following measurements were made a short distance below its junction with Clear Creek:

1905—July 5: Discharge, 108 second-feet.
August 8: Discharge, 79 second-feet.
September 1: Discharge, 93 second-feet.
October 2: Discharge, 83 second-feet.
December 15: Discharge, 74 second-feet.
1906—June 1: Discharge, 498 second-feet.
July 6: Discharge, 250 second-feet.
August 7: Discharge, 139 second-feet.

The following measurements were made at wagon bridge on east side of Big Meadow and below its junction with Rock Creek:

1905—June 23: Discharge, 169 second-feet.
1906—September 1: Discharge, 232 second-feet.

*Hot Springs Valley Creek at Hot Springs Valley.*—This creek is a tributary of Warner Creek. The following measurements were made a short distance above its junction with Warner Creek:

1905—June 28: Discharge, 44 second-feet.
August 2: Discharge, 30 second-feet.
August 30: Discharge, 28 second-feet.
October 4: Discharge, 25 second-feet.
1906—May 23: Discharge, 117 second-feet.
July 11: Discharge, 80 second-feet.
September 4: Discharge, 35 second-feet.

*Hosselkus ditch near Genesee, Cal.*—This ditch diverts water from Little Grizzly Creek. A measurement was made August 20, 1906, 1½ miles southwest of Genesee post-office and a short distance below point of diversion:

Width, 5 feet; area, 3.5 square feet; discharge, 5 second-feet.

*Indian Creek.*—This creek is one of the principal tributaries of North Fork of Feather River. The following measurements were made a short distance above its mouth during 1905:

June 16: Discharge, 321 second-feet.
September 8: Discharge, 106 second-feet.

*Indian Creek near Genesee, Cal.*—A measurement of this stream was made August 21, 1906, one-half mile northwest of Flournoy's and above its junction with Red Clover Creek:

Width, 6.5 feet; area, 4.3 square feet; discharge, 3.8 second-feet.

*King Creek at Hot Springs Valley, Cal.*—This stream is a tributary of Warner Creek. The following measurements were made at crossing of the Prattville-Lassen Peak road, one-half mile above the junction with Warner Creek:

1905—June 28: Discharge, 66 second-feet.
August 2: Discharge, 29 second-feet.
August 30: Discharge, 18 second-feet.
October 4: Discharge, 12.6 second-feet.
1906—May 22: Discharge, 151 second-feet.
July 11: Discharge, 117 second-feet.

*Little Grizzly Creek near Genesee, Cal.*—This stream is a tributary of Indian Creek. A measurement was made August 20, 1906, 1½ miles southwest of Genesee post-office, above the diversion of the Hosselkus ditch:

Width, 21 feet; area, 21 square feet; discharge, 14.7 second-feet.

*Middle Fork of Feather River near Beckwith, Cal.*—A measurement of this stream was made August 12, 1906, 2 miles west of Beckwith, Cal., and one-half mile above its junction with Grizzly Creek:

Width, 10 feet; area, 4.4 square feet; discharge, 5 second-feet.

*North Arm Creek near Taylorsville, Cal.*—This stream is a tributary of Indian Creek. A measurement was made August 22, 1906, at "Dead Fall" bridge, 1¾ miles north of Taylorsville, Cal.:

Width, 14 feet; area, 12.4 square feet; discharge, 5.1 second-feet.

*North Fork of Feather River near Tyler, Cal.*—The following measurements were made at the bridge on the Prattville-Red Bluff road:

1905—June 29: Discharge, 52 second-feet.
August 2: Discharge, 17.4 second-feet.
August 30: Discharge, 12.4 second-feet.
October 4: Discharge, 11.4 second-feet.
1906—May 23: Discharge, 91 second-feet.
July 10: Discharge, 117 second-feet.

*North Fork of Feather River.*—The following measurements were made a short distance above its junction with Warner Creek:

1905—August 30: Discharge, 84 second-feet.
October 3: Discharge, 64 second-feet.
1906—May 23: Discharge, 506 second-feet.
July 11: Discharge, 323 second-feet.

*North Fork of Feather River near Prattville, Cal.*—The following measurements were made at Olsen's ranch, 8 miles northwest of Prattville, Cal.:

1905—June 30: Discharge, 286 second-feet.
August 4: Discharge, 188 second-feet.
August 29: Discharge, 146 second-feet.
October 3: Discharge, 128 second-feet.
1906—March 1: Discharge, 164 second-feet.
May 22: Discharge, 805 second-feet.
July 10: Discharge, 647 second-feet.

*Prattville Branch of North Fork of Feather River at Prattville, Cal.*—The following measurements were made 800 feet above its junction with North Fork of Feather River:

1905—June 12: Discharge, 186 second-feet.
July 7: Discharge, 196 second-feet.
August 14: Discharge, 180 second-feet.
September 2: Discharge, 179 second-feet.
1906—January 5: Discharge, 147 second-feet.
June 29: Discharge, 303 second-feet.
August 3: Discharge, 227 second-feet.

*Red Clover Creek near Genesee, Cal.*—This stream is a tributary of Indian Creek. A measurement was made August 21, 1906, 1¼ miles southeast of Flournoy's and above diversion of Flournoy's ditch:

Width, 10 feet; area, 11 square feet; discharge, 21 second feet.

*Rock Creek near Prattville, Cal.*—This stream is a tributary of Hamilton Branch of North Fork of Feather River. The following measurements were made at bridge on Prattville-Susanville road:

1905—June 24: Discharge, 12 second-feet.
July 5: Discharge, 7.4 second-feet.
August 8: Discharge, 5 second-feet.
September 1: Discharge, 2.1 second-feet.
October 2: Discharge, 1.5 second-feet.
December 15: Discharge, 0.5 second-foot.
1906—June 1: Discharge, 85 second-feet.
July 6: Discharge, 25 second-feet.
August 7: Discharge, 25 second-feet.

*South Fork of Feather River near Enterprise, Cal.*—The following measurements, which include the flow in the Enterprise ditch, were made a short distance above its junction with Feather River during 1905:

June 11: Discharge, 246 second-feet.
July 25: Discharge, 64 second-feet.
August 18: Discharge, 48 second-feet.
September 17: Discharge, 34 second-feet.

*Spanish Creek near Quincy, Cal.*—This stream is a tributary of Indian Creek. A measurement was made September 9, 1906, at the wagon bridge, 2½ miles northeast of Quincy, Cal.:

Width, 40 feet; area, 40 feet; discharge, 44 second-feet.

*Squaw Queen Creek near Genesee, Cal.*—This stream is a tributary of Red Clover Creek. A measurement was made August 21, 1906, three-fourths mile southeast of Flournoy and 500 feet above its junction with Clover Creek:

Width, 6 feet; area, 3.6 square feet; discharge, 2.3 second-feet.

*Warner Creek near Chester, Cal.*—This stream is a tributary of the North Fork of Feather River. The following measurements were made at bridge on Prattville-Red Bluff road:

1905—June 30: Discharge, 140 second-feet.
August 5: Discharge, 81 second-feet.
August 29: Discharge, 63 second-feet.
October 3: Discharge, 61 second-feet.
1906—May 23: Discharge, 320 second-feet.
July 10: Discharge, 268 second-feet.
September 4: Discharge, 95 second-feet.

*Ward Creek near Genesee, Cal.*—This stream is a tributary of Indian Creek. A measurement was made August 22, 1906, at Phelan's ranch house, 1½ miles above its junction with Indian Creek:

Width, 8 feet; area, 3.2 square feet; discharge, 8.1 second-feet.

*Willow Creek near Chester, Cal.*—This stream is a tributary of North Fork of Feather River. The following measurements were made at the ford on the Prattville-Red Bluff road:

1905—June 29: Discharge, 4.1 second-feet.
August 2: Discharge, 4.0 second-feet.
October 4: Discharge, 2.5 second-feet.
1906—May 23: Discharge, 40 second-feet.

*Wolf Creek near Greenville, Cal.*—This stream is a tributary of Indian Creek, discharging through swamp in west arm of Indian Valley. A measurement was made August 23, 1906, one-fourth mile southwest of Greenville, Cal., above its junction with North Canyon, a stream which discharges from Round Valley Reservoir. A diversion of 3.4 second-feet for irrigation is made above point of measurement.

Width, 3 feet; area, 1.2 square feet; discharge, 1.8 second-feet.

### PRECIPITATION AND EVAPORATION DATA.

The following tables give the total precipitation and evaporation, in inches, by months at Prattville, Cal.:

*Precipitation and evaporation at Prattville, Cal.*

PRECIPITATION.

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905 | ..... | ..... | ..... | ..... | ..... | ..... | 0.00 | 0.17 | 0.70 | 0.28 | 2.77 | 1.74 | ..... |
| 1906 | 16.20 | 6.45 | 14.42 | 0.73 | 4.99 | 1.42 | 0.34 | 0.15 | 0.53 | 0.20 | 3.91 | 14.68 | 64.02 |

EVAPORATION.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905 | ..... | ..... | ..... | ..... | ..... | ..... | 3.81 | 4.31 | 3.80 | 2.72 | 1.50 | 1.00 | ..... |
| 1906 | 1.30 | 0.95 | 1.16 | 2.84 | 2.58 | 2.77 | 3.86 | 3.42 | 2.72 | 3.06 | 1.28 | 0.41 | 26.35 |

## YUBA RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Yuba River is a tributary of Feather River, which it enters at Marysville, 30 miles above the junction of Feather and Sacramento rivers. The entire drainage area of the Yuba is about 1,327 square miles, of which about 1,220 square miles are above the gaging station at Smartsville. Its extreme length is about 60 miles, and extreme width 56 miles. In the lower stretches of the river, at the location of the present gaging station and in the valley below, the channel has been filled to a considerable depth with débris from hydraulic mining.

The drainage basin is subdivided into 5 small basins, namely: North Fork, with a drainage area of 491.6 square miles; Middle Fork, with a drainage area of 218 square miles; South Fork, with a drainage area of 360 square miles; Deer Creek, with a drainage of 89.6 square miles, and Dry Creek, with a drainage area of 105.5 square miles. The

latter tributary discharges into the main river about 5 miles below the gaging station. The watershed rises gently in rounded and broken mountains, to the crest of the Sierra Nevada, which at the headwaters of the Yuba has a mean elevation of about 8,200 feet, with peaks rising to a height of 9,100 feet. From Mount Lincoln—a peak common to the watersheds of the Yuba, American, and Truckee rivers—to a point about 2½ miles northeast of Mount Weber, the summit of the Sierra Nevada divides the watershed of Yuba River from that of Truckee River, which discharges into Humboldt Basin. Farther north from Mount Weber there is a secondary crest which divides the watersheds of Yuba and Feather rivers, the watershed of the latter stream reaching farther east to a less elevated divide in which the passes are lower than those of the easterly crest.

The western and lower portions of the Yuba drainage basin are composed of slate and kindred rock, very much eroded and merging into the gravel and alluvial deposits of the Sacramento Valley. The upper portions of the basin are composed principally of lavas and granites, all depely eroded, particularly the lavas. A stratum of serpentine traverses the watershed of the Yuba River in a direction generally parallel with the crest of the Sierra. North Fork rises in lavas which vary much in composition and hardness, but which generally have a deep soil covering, with timber and brush growth. Middle Fork rises in similar lavas and granite. The main and tributary streams fall rapidly, and their canyons head well up in the mountains. The sides of these canyons are covered with timber and brush, which, with the deep soil, retain the moisture and feed numerous perennial springs. In the case of North Fork this is particularly noticeable. The forests of its watersheds make a reliable and constant stream. The mean annual precipitation for the basins of North and Middle forks is about 54 inches. Warm rains on soft snow sometimes give high flood discharge, but snow remains on the higher peaks until midsummer. The headwaters of South Fork lie upon a broad granite surface into which the streams have not cut deeply until the main stream reaches a point 16 miles from the summit, where it drops rapidly into a deeply eroded canyon. This part of the basin has a precipitation annually of about 60 inches. The entire drainage area of the Yuba contains nearly 100 small glacial lakes.

### YUBA RIVER NEAR SMARTSVILLE, CAL.

This station was established June 2, 1903. It is located at what is called "The Narrows," 1 mile from Smartsville, Cal., 18 miles from the Southern Pacific Railroad station at Wheatland, Cal., and 20 miles from Marysville, Cal. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 160, where are given also references to publications that contain data for previous years.

*Discharge measurements of Yuba River near Smartsville, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 4 | J. R. McKeel | 73 | 147 | 1.70 | 590 |
| January 11 | do | 79 | 153 | 1.80 | 601 |
| January 25 | do | 190 | 1,400 | 6.30 | 3,650 |
| January 30 | do | 189 | 984 | 5.70 | 2,680 |
| February 4 | do | 187 | 663 | 5.40 | 2,270 |
| February 9 | F. R. S. Buttemer | 189 | 575 | 5.32 | 1,930 |
| February 11 | J. R. McKeel | 188 | 631 | 5.50 | 2,460 |
| February 15 | R. S. Hawley | 260 | 1,570 | 8.00 | 8,990 |
| March 9 | do | 210 | 1,020 | 6.85 | 5,340 |
| March 10 | do | 210 | 1,020 | 6.90 | 5,550 |
| March 23 | do | 280 | 1,850 | 9.80 | 17,400 |
| March 24 | do | 300 | 2,660 | 12.20 | 29,500 |
| April 10 | Hawley and Sawyer | 240 | 1,290 | 7.20 | 8,280 |
| April 17 | W. C. Sawyer | 242 | 1,340 | 7.20 | 8,100 |
| April 18 | do | 240 | 1,380 | 7.20 | 8,270 |
| April 26 | do | 210 | 1,320 | 6.65 | 6,600 |
| May 3 | do | 257 | 1,650 | 7.70 | 11,500 |
| May 4 | do | 257 | 1,580 | 7.70 | 10,300 |
| May 5 | do | 260 | 1,820 | 8.15 | 13,200 |
| May 18 | do | 173 | 1,180 | 6.07 | 6,420 |
| July 10 | R. S. Hawley | 162 | 1,010 | 2.47 | 4,440 |
| July 11 | do | 160 | 965 | 2.23 | 4,020 |
| July 24 | do | 156 | 710 | 0.95 | 1,870 |
| July 25 | do | 156 | 679 | 0.75 | 1,580 |
| August 6 | J. R. McKeel | 150 | 560 | 9.80 | 1,000 |
| August 20 | do | 150 | 505 | 9.45 | 701 |
| August 30 | do | 150 | 484 | 9.35 | 661 |
| September 9 | do | 150 | 459 | 9.25 | 548 |
| September 16 | do | 150 | 469 | 9.30 | 577 |
| September 24 | do | 150 | 487 | 9.20 | 575 |
| October 2 | R. S. Hawley | 147 | 440 | 9.10 | 422 |
| October 25 | do | 146 | 453 | 9.10 | 423 |

*Daily gage height, in feet, of Yuba River near Smartsville, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.8 | 5.5 | 7.4 | 9.7 | 7.1 | 6.3 | 3.5 | 10.0 | 9.4 | 9.1 | 9.0 | 9.3 |
| 2 | 1.7 | 5.5 | 7.0 | 8.7 | 7.5 | 6.4 | 3.8 | 9.9 | 9.3 | 9.1 | 9.1 | 9.3 |
| 3 | 1.7 | 5.5 | 7.5 | 8.0 | 7.9 | 6.7 | 4.0 | 9.9 | 9.3 | 9.1 | 9.1 | 9.3 |
| 4 | 1.7 | 5.4 | 7.3 | 7.5 | 8.0 | 10.0 | 3.7 | 9.8 | 9.3 | 9.1 | 12.7 | 9.3 |
| 5 | 1.7 | 5.4 | 6.9 | 7.3 | 8.1 | 8.0 | 3.5 | a 9.8 | 9.3 | 9.1 | 10.6 | 9.3 |
| 6 | 1.7 | 5.4 | 6.7 | 7.2 | 8.0 | 7.0 | 3.2 | 9.8 | 9.3 | 9.0 | 10.0 | 9.3 |
| 7 | 1.7 | 5.3 | 6.8 | 7.2 | 8.0 | 6.5 | 3.0 | 9.8 | 9.3 | 9.0 | 9.7 | 9.3 |
| 8 | 1.7 | 5.3 | 6.8 | 7.3 | 8.0 | 6.1 | 2.8 | 9.7 | 9.3 | 9.0 | 9.5 | 10.9 |
| 9 | 1.6 | 5.3 | 6.8 | 7.3 | 8.2 | 6.3 | 2.6 | 9.7 | 9.2 | 9.0 | 9.5 | 10.2 |
| 10 | 1.8 | 5.6 | 6.9 | 7.3 | 8.1 | a 6.7 | 2.5 | 9.7 | 9.2 | 9.0 | 9.4 | 10.9 |
| 11 | 1.8 | 5.5 | 7.0 | 7.1 | 8.4 | 7.0 | 2.1 | 9.7 | 9.2 | 9.0 | 9.4 | 17.0 |
| 12 | 4.7 | 5.4 | 12.0 | 7.0 | 7.6 | 8.0 | 2.4 | a 9.6 | 9.2 | 9.0 | 9.4 | 12.7 |
| 13 | 9.7 | 5.3 | 8.8 | 7.1 | 7.0 | 6.6 | 2.3 | 9.6 | 9.2 | 9.0 | 9.4 | 11.7 |
| 14 | 8.5 | 5.4 | 8.8 | 7.0 | a 7.1 | 5.7 | 2.2 | 9.6 | 9.2 | 9.0 | 9.4 | 11.0 |
| 15 | 11.0 | 8.3 | 8.1 | 7.2 | 7.3 | 5.7 | 1.8 | 9.6 | 9.3 | 9.0 | 9.4 | 10.8 |
| 16 | 11.0 | 6.7 | 7.5 | 7.2 | 6.3 | 7.0 | 1.7 | 9.6 | 9.3 | 9.0 | 9.6 | 10.7 |
| 17 | 9.7 | 6.1 | 7.2 | 7.3 | 6.2 | 5.8 | 1.6 | 9.5 | 9.2 | 9.1 | 9.5 | 10.6 |
| 18 | 17.0 | 6.4 | a 6.9 | 7.3 | 6.1 | 5.0 | 1.6 | 9.5 | 9.2 | 9.1 | 9.4 | 10.5 |
| 19 | 13.0 | 8.5 | 6.7 | 7.4 | 6.2 | 6.2 | 1.4 | 9.5 | a 9.2 | 9.1 | 9.3 | 10.4 |
| 20 | 8.9 | 7.0 | 6.6 | 7.5 | 6.3 | 5.9 | 1.2 | 9.5 | 9.2 | 9.1 | 9.3 | 10.4 |
| 21 | 8.0 | 8.4 | 7.1 | 7.5 | 6.2 | 5.3 | 1.1 | 9.5 | 9.2 | 9.1 | 9.3 | 10.4 |
| 22 | 7.4 | 7.4 | 9.6 | 7.5 | 6.1 | 5.0 | 1.0 | 9.5 | 9.2 | 9.1 | 9.3 | 10.4 |
| 23 | 7.0 | 7.7 | 10.0 | 7.3 | 5.9 | 5.1 | 1.0 | 9.5 | 9.2 | 9.1 | 9.3 | 11.4 |
| 24 | 6.7 | 7.7 | 12.2 | 7.0 | 5.5 | 4.3 | 0.9 | 9.5 | 9.2 | 9.0 | 9.3 | 11.4 |
| 25 | 6.3 | 7.8 | 11.6 | 6.7 | 6.6 | 4.2 | 0.8 | 9.5 | 9.2 | 9.0 | 9.3 | 15.4 |
| 26 | 6.1 | 7.4 | 12.4 | 6.8 | 8.8 | 4.0 | .7 | a 9.4 | 9.2 | 9.0 | 9.3 | 18.9 |
| 27 | 6.0 | 8.5 | 9.5 | 6.6 | 8.7 | 3.8 | .6 | 9.4 | 9.2 | 9.0 | 9.3 | 13.8 |
| 28 | a 5.9 | 8.0 | 8.6 | 6.4 | 9.0 | 3.7 | .5 | 9.4 | 9.2 | 9.0 | 9.3 | 12.8 |
| 29 | 5.8 | ..... | 8.0 | 6.7 | 7.7 | 3.5 | a .4 | a 9.4 | 9.2 | 9.0 | 9.2 | 11.8 |
| 30 | 5.7 | ..... | 9.4 | 6.8 | 6.7 | 3.5 | .3 | 9.4 | 9.1 | 9.0 | 9.3 | 12.4 |
| 31 | 5.6 | ..... | 14.0 | ..... | 6.3 | ..... | .2 | 9.4 | ..... | 9.0 | ..... | 12.4 |

a Estimated.

NOTE.—The datum of the gage was lowered 10 feet August 1.

*Daily discharge, in second-feet, of Yuba River near Smartsville, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 600 | 2,390 | 6,810 | 18,100 | 9,000 | 8,900 | 5,200 | 1,040 | 620 | 440 | 380 | 560 |
| 2 | 555 | 2,390 | 5,550 | 13,500 | 10,500 | 9,350 | 6,000 | 920 | 560 | 440 | 440 | 560 |
| 3 | 555 | 2,390 | 7,150 | 11,700 | 12,400 | 10,500 | 6,600 | 920 | 560 | 440 | 440 | 560 |
| 4 | 555 | 2,250 | 6,480 | 9,100 | 11,600 | 25,600 | 6,000 | 860 | 560 | 440 | 5,000 | 560 |
| 5 | 555 | 2,250 | 5,260 | 8,600 | 13,000 | 16,500 | 5,800 | 860 | 560 | 440 | 1,540 | 560 |
| 6 | 555 | 2,250 | 4,730 | 8,300 | 12,500 | 12,200 | 5,200 | 860 | 560 | 380 | 1,040 | 560 |
| 7 | 555 | 2,120 | 4,990 | 8,350 | 12,500 | 10,400 | 5,000 | 860 | 560 | 380 | 800 | 560 |
| 8 | 555 | 2,120 | 4,990 | 8,700 | 12,500 | 9,200 | 4,800 | 800 | 560 | 380 | 680 | 1,880 |
| 9 | 515 | 2,120 | 4,990 | 8,700 | 13,600 | 10,100 | 4,550 | 800 | 500 | 380 | 680 | 1,170 |
| 10 | 600 | 2,540 | 5,260 | 8,600 | 13,200 | 11,700 | 4,520 | 800 | 500 | 380 | 520 | 1,880 |
| 11 | 600 | 2,390 | 5,550 | 8,000 | 14,400 | 13,100 | 3,720 | 800 | 500 | 380 | 520 | 16,800 |
| 12 | 3,590 | 2,250 | 28,400 | 7,700 | 11,400 | 18,000 | 4,320 | 740 | 500 | 380 | 520 | 5,850 |
| 13 | 16,900 | 2,120 | 12,500 | 7,950 | 8,600 | 11,700 | 4,120 | 740 | 500 | 380 | 520 | 4,100 |
| 14 | 11,500 | 2,250 | 12,500 | 7,500 | 9,300 | 8,700 | 3,920 | 740 | 500 | 380 | 520 | 3,100 |
| 15 | 18,900 | 10,200 | 9,400 | 8,100 | 10,000 | 8,800 | 3,130 | 740 | 560 | 380 | 520 | 2,850 |
| 16 | 18,900 | 4,730 | 7,150 | 8,100 | 6,950 | 14,100 | 2,950 | 740 | 560 | 380 | 740 | 2,700 |
| 17 | 16,900 | 3,400 | 6,160 | 8,500 | 6,700 | 9,450 | 2,780 | 680 | 500 | 440 | 680 | 2,600 |
| 18 | 48,000 | 4,010 | 5,260 | 8,500 | 6,500 | 7,200 | 2,780 | 680 | 500 | 440 | 520 | 2,500 |
| 19 | 33,000 | 11,100 | 4,730 | 8,900 | 6,800 | 11,700 | 2,450 | 680 | 500 | 440 | 560 | 2,350 |
| 20 | 13,000 | 5,550 | 4,480 | 9,200 | 7,200 | 10,300 | 2,160 | 680 | 500 | 440 | 560 | 2,350 |
| 21 | 9,000 | 10,700 | 5,850 | 9,200 | 7,150 | 8,400 | 2,030 | 680 | 500 | 440 | 560 | 2,350 |
| 22 | 6,810 | 6,810 | 16,400 | 9,200 | 7,000 | 8,200 | 1,900 | 680 | 500 | 440 | 560 | 2,350 |
| 23 | 5,550 | 7,850 | 18,400 | 8,600 | 6,500 | 8,100 | 1,900 | 680 | 500 | 440 | 560 | 3,700 |
| 24 | 4,730 | 7,850 | 29,400 | 7,650 | 5,750 | 6,100 | 1,880 | 680 | 500 | 380 | 560 | 3,700 |
| 25 | 3,800 | 8,230 | 26,400 | 6,800 | 8,900 | 6,000 | 1,760 | 680 | 500 | 380 | 560 | 11,300 |
| 26 | 3,400 | 6,810 | 30,400 | 7,050 | 18,700 | 5,700 | 1,650 | 620 | 500 | 380 | 560 | 22,800 |
| 27 | 3,210 | 11,100 | 15,900 | 7,000 | 18,200 | 5,400 | 1,540 | 620 | 500 | 380 | 560 | 8,000 |
| 28 | 3,040 | 9,000 | 11,600 | 6,450 | 20,100 | 5,300 | 1,440 | 620 | 500 | 380 | 560 | 6,000 |
| 29 | 2,860 | ..... | 9,000 | 7,350 | 13,700 | 5,000 | 1,340 | 620 | 500 | 380 | 500 | 4,300 |
| 30 | 2,700 | ..... | 15,400 | 7,800 | 10,000 | 5,100 | 1,250 | 620 | 440 | 380 | 560 | 5,300 |
| 31 | 2,540 | ..... | 40,600 | ..... | 8,800 | ..... | 1,170 | 620 | ..... | 380 | ..... | 5,300 |

NOTE.—These discharges were obtained partly by rating tables and partly by the indirect method for shifting channels.

*Monthly discharge of Yuba River near Smartsville, Cal., for 1906.*

[Drainage area, 1,220 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 48,000 | 515 | 7,560 | 465,000 | 6.20 | 7.15 |
| February | 11,100 | 2,120 | 4,970 | 276,000 | 4.07 | 4.24 |
| March | 40,600 | 4,480 | 12,000 | 738,000 | 9.84 | 11.34 |
| April | 18,100 | 6,450 | 8,770 | 522,000 | 7.19 | 8.02 |
| May | 20,100 | 5,750 | 10,800 | 664,000 | 8.85 | 10.20 |
| June | 25,600 | 5,000 | 10,000 | 595,000 | 8.20 | 9.15 |
| July | 6,600 | 1,170 | 3,350 | 206,000 | 2.75 | 3.17 |
| August | 1,040 | 620 | 744 | 45,700 | .610 | .70 |
| September | 620 | 440 | 520 | 30,900 | .426 | .48 |
| October | 440 | 380 | 403 | 24,800 | .330 | .38 |
| November | 5,000 | 380 | 757 | 45,000 | .620 | .69 |
| December | 22,800 | 560 | 4,130 | 254,000 | 3.39 | 3.91 |
| The year | 48,000 | 380 | 5,330 | 3,870,000 | 4.37 | 59.43 |

NOTE.—Values are rated as follows: February and March, excellent; June, November, and December, fair, on account of the lack of measurements; remainder of 1906, good.

## BEAR RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Bear River drains an area of 287 square miles between Yuba and American rivers. Its headwaters do not reach back to the crest of the range, so that it seldom receives precipitation in the form of lasting snow. It is torrential in character, having no forested areas except

in its upper portion. The rainfall records kept by the Central Pacific from Auburn to Emigrant Gap are indicative of the precipitation in the southern part of its basin. A 28-year record at Grass Valley in the northern portion of its watershed gives a mean of 49.41 inches.

### BEAR RIVER ABOVE WHEATLAND, CAL.

This station was established on October 8, 1904. It is located about 800 feet below McCourtney Crossing and 8 miles above Wheatland. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 165, where are given also references to publications that contain data for previous years.

*Discharge measurements of Bear River above Wheatland, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 10 | F. R. S. Buttemer | 123 | 117 | 4.55 | 337 |
| February 26 | do | 156 | 323 | 6.10 | 1,430 |
| March 10 | do | 118 | 222 | 4.97 | 862 |
| March 18 | do | 137 | 284 | 5.60 | 1,330 |
| April 12 | W. C. Sawyer | 144 | 232 | 5.34 | 981 |
| April 19 | do | 139 | 181 | 4.83 | 650 |
| April 27 | do | 140 | 186 | 4.85 | 664 |
| April 27 | do | 141 | 236 | 5.22 | 979 |
| May 19 | do | 130 | 122 | 4.02 | 274 |
| July 12 | R. S. Hawley | 53 | 57 | 3.57 | 168 |
| July 24 | do | 58 | 38 | 3.30 | 73 |
| July 25 | do | 75 | 61 | 3.28 | 64 |
| October 3 | do | 25 | 20 | 3.06 | 31 |

*Daily gage height, in feet, of Bear River above Wheatland, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.2 | 4.6 | 6.0 | 8.7 | 4.5 | 5.2 | 3.9 | 3.2 | 3.0 | 3.0 | 3.1 | 3.3 |
| 2 | 3.1 | 4.6 | 5.7 | 7.3 | 4.6 | 5.0 | 3.9 | 3.2 | 3.0 | 3.0 | 3.1 | 3.3 |
| 3 | 3.1 | 4.5 | 5.5 | 6.8 | 4.5 | 5.0 | 3.8 | 3.1 | 3.0 | 3.0 | 3.2 | 3.3 |
| 4 | 3.1 | 4.5 | 6.5 | 6.4 | 4.4 | 6.0 | 3.8 | 3.1 | 3.0 | 3.0 | 4.45 | 3.3 |
| 5 | 3.0 | 4.5 | 5.8 | 6.2 | 4.4 | 5.4 | 3.7 | 3.1 | 3.0 | 3.0 | 3.9 | 3.3 |
| 6 | 3.0 | 4.4 | 5.5 | 6.0 | 4.4 | 5.7 | 3.7 | 3.1 | 3.0 | 3.0 | 3.6 | 3.3 |
| 7 | 3.1 | 4.4 | 5.3 | 5.8 | 4.3 | 5.2 | 3.7 | 3.1 | 3.0 | 3.0 | 3.5 | 3.3 |
| 8 | 3.0 | 4.4 | 5.1 | 5.6 | 4.3 | 5.0 | 3.7 | 3.1 | 3.0 | 3.0 | 3.4 | 4.65 |
| 9 | 3.0 | 4.5 | 5.0 | 5.4 | 4.3 | 4.8 | 3.6 | 3.1 | 3.0 | 3.0 | 3.3 | 3.9 |
| 10 | 3.0 | 4.6 | 4.9 | 5.5 | 4.3 | 4.7 | 3.6 | 3.1 | 3.0 | 3.0 | 3.3 | 3.9 |
| 11 | 3.0 | 4.7 | 4.8 | 5.7 | 4.4 | 4.6 | 3.6 | 3.1 | 3.0 | 3.0 | 3.3 | 11.9 |
| 12 | 3.9 | 4.5 | 7.55 | 5.4 | 4.4 | 4.7 | 3.5 | 3.1 | 3.0 | 3.0 | 3.3 | 9.2 |
| 13 | 10.35 | 4.5 | 6.3 | 5.2 | 4.3 | 4.5 | 3.5 | 3.0 | 3.0 | 3.1 | 3.3 | 6.6 |
| 14 | 6.8 | 4.4 | 7.6 | 5.1 | 4.2 | 4.5 | 3.5 | 3.0 | 3.1 | 3.1 | 3.3 | 4.6 |
| 15 | 10.5 | 6.4 | 8.7 | 5.0 | 4.6 | 4.4 | 3.4 | 3.0 | 3.1 | 3.0 | 3.3 | 4.2 |
| 16 | 11.65 | 5.4 | 6.6 | 5.0 | 4.3 | 4.9 | 3.4 | 3.0 | 3.1 | 3.0 | 3.4 | 4.0 |
| 17 | 8.5 | 5.1 | 6.1 | 4.9 | 4.2 | 4.5 | 3.4 | 3.1 | 3.1 | 3.1 | 3.3 | 3.9 |
| 18 | 14.55 | 4.9 | 5.7 | 4.9 | 4.2 | 4.4 | 3.3 | 3.0 | 3.1 | 3.1 | 3.3 | 3.8 |
| 19 | 12.25 | 6.9 | 5.4 | 4.8 | 4.1 | 4.3 | 3.3 | 3.0 | 3.1 | 3.1 | 3.3 | 3.8 |
| 20 | 9.5 | 5.9 | 5.2 | 4.8 | 4.1 | 4.3 | 3.3 | 3.0 | 3.1 | 3.1 | 3.3 | 3.8 |
| 21 | 6.5 | 7.7 | 5.7 | 4.8 | 4.1 | 4.2 | 3.3 | 3.0 | 3.0 | 3.1 | 3.3 | 3.7 |
| 22 | 6.0 | 6.7 | 7.2 | 4.7 | 4.1 | 4.2 | 3.3 | 3.0 | 3.0 | 3.1 | 3.3 | 3.7 |
| 23 | 5.7 | 7.3 | 6.8 | 4.75 | 4.0 | 4.2 | 3.2 | 3.0 | 3.0 | 3.1 | 3.3 | 4.7 |
| 24 | 5.4 | 6.5 | 11.7 | 4.85 | 4.0 | 4.2 | 3.3 | 3.0 | 3.1 | 3.1 | 3.3 | 4.2 |
| 25 | 5.2 | 6.9 | 10.5 | 5.1 | 4.45 | 4.1 | 3.3 | 3.0 | 3.1 | 3.1 | 3.3 | 6.45 |
| 26 | 5.0 | 6.1 | 12.3 | 4.8 | 5.6 | 4.1 | 3.2 | 3.0 | 3.1 | 3.1 | 3.2 | 10.75 |
| 27 | 4.9 | 6.55 | 8.3 | 4.9 | 6.85 | 4.1 | 3.2 | 3.0 | 3.1 | 3.1 | 3.2 | 8.50 |
| 28 | 4.8 | 7.0 | 7.2 | 5.0 | 8.65 | 4.1 | 3.2 | 3.0 | 3.1 | 3.1 | 3.3 | 6.0 |
| 29 | 4.7 | ..... | 6.8 | 4.7 | 6.6 | 4.0 | 3.2 | 3.0 | 3.1 | 3.0 | 3.3 | 5.3 |
| 30 | 4.7 | ..... | 7.4 | 4.7 | 5.9 | 4.0 | 3.2 | 3.0 | 3.1 | 3.1 | 3.3 | 4.9 |
| 31 | 4.6 | ..... | 15.25 | ..... | 5.4 | ..... | 3.2 | 3.0 | ..... | 3.1 | ..... | 7.0 |

*Rating table for Bear River above Wheatland, Cal., for 1904–1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.00 | 20 | 4.10 | 328 | 5.20 | 1,015 | 6.60 | 2,640 | 8.80 | 6,640 |
| 3.10 | 33 | 4.20 | 375 | 5.30 | 1,105 | 6.80 | 2,935 | 9.00 | 7,060 |
| 3.20 | 49 | 4.30 | 425 | 5.40 | 1,200 | 7.00 | 3,250 | 10.00 | 9,160 |
| 3.30 | 69 | 4.40 | 475 | 5.50 | 1,300 | 7.20 | 3,575 | 11.00 | 11,360 |
| 3.40 | 92 | 4.50 | 530 | 5.60 | 1,405 | 7.40 | 3,910 | 12.00 | 13,660 |
| 3.50 | 118 | 4.60 | 585 | 5.70 | 1,515 | 7.60 | 4,265 | 13.00 | 15,960 |
| 3.60 | 146 | 4.70 | 645 | 5.80 | 1,625 | 7.80 | 4,635 | 14.00 | 18,360 |
| 3.70 | 177 | 4.80 | 710 | 5.90 | 1,740 | 8.00 | 5,020 | | |
| 3.80 | 210 | 4.90 | 780 | 6.00 | 1,860 | 8.20 | 5,410 | | |
| 3.90 | 246 | 5.00 | 855 | 6.20 | 2,105 | 8.40 | 5,810 | | |
| 4.00 | 285 | 5.10 | 930 | 6.40 | 2,365 | 8.60 | 6,220 | | |

NOTE.—This table is based on discharge measurements made during 1904–1906, and is well defined between gage heights 3.1 feet and 5.1 feet.

*Monthly discharge of Bear River above Wheatland, Cal., for 1906.*

[Drainage area, 263 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 19,700 | 20 | 3,130 | 192,000 | 11.90 | 13.72 |
| February | 4,450 | 475 | 1,500 | 83,300 | 5.70 | 5.94 |
| March | 21,400 | 710 | 3,970 | 244,000 | 15.10 | 17.41 |
| April | 6,430 | 645 | 1,390 | 82,700 | 5.28 | 5.89 |
| May | 6,320 | 285 | 870 | 53,500 | 3.31 | 3.82 |
| June | 1,860 | 285 | 644 | 38,300 | 2.45 | 2.73 |
| July | 246 | 49 | 113 | 6,950 | .430 | .50 |
| August | 49 | 20 | 26.5 | 1,630 | .101 | .12 |
| September | 33 | 20 | 26.1 | 1,550 | .099 | .11 |
| October | 33 | 20 | 26.7 | 1,640 | .102 | .12 |
| November | 502 | 33 | 90.7 | 5,400 | .345 | .38 |
| December | 13,400 | 69 | 1,770 | 109,000 | 6.73 | 7.76 |
| The year | 21,400 | 20 | 1,130 | 820,000 | 4.29 | 58.50 |

NOTE.—These values are fair.

## AMERICAN RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

American River drains an area of about 2,000 square miles of the western slope of the Sierra Nevada. This drainage basin lies between those of the Bear and Yuba rivers on the north and that of Consumnes River on the south. It has three main forks, heading in the summit of the range, which reaches an elevation of about 9,000 feet. The country lying between these main forks is drained by numerous small tributaries. The formation in the higher and greater portions of this basin is of granite, with a considerable timber growth. The flow is rather torrential during the winter months, due to the large area of barren and sparsely timbered country in the lower portion of the watershed. The precipitation on the higher elevations is in the form of snow, which usually melts late in the spring. Rainfall records have been kept along the line of the Central Pacific Railroad, which follows the ridge to the north of North Fork.

The mean annual rainfall at Auburn is 33.40 inches, that at Colfax 47.4 inches, and at Cisco and Emigrant Gap about 50 inches. At Georgetown, between North and Middle forks, a 30-year record has an average of 56.72 inches, and at Placerville, above South Fork, another of about the same length shows 43.58 inches.

There are several small lakes in the upper reaches of this basin, the capacity of a few having been increased by the construction of low dams at their outlets. Their water is stored for mining purposes during the low-water flow and is used entirely within the drainage basin.

### AMERICAN RIVER NEAR FAIROAKS, CAL.

This station was established November 3, 1904, at Fairoaks Bridge, near Fairoaks. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 176, where are given also references to publications that contain data for previous years.

*Discharge measurements of American River near Fairoaks, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 13 | F. R. S. Buttemer | 300 | 1,400 | 3.66 | 2,090 |
| March 3 | do | 352 | 2,180 | 5.95 | 6,480 |
| April 6 | R. S. Hawley | 360 | 2,490 | 7.30 | 9,670 |
| April 13 | W. C. Sawyer | 376 | 2,580 | 7.26 | 9,970 |
| April 23 | do | 367 | 2,940 | 8.54 | 13,800 |
| April 30 | do | 352 | 2,450 | 7.24 | 9,420 |
| April 30 | do | 352 | 2,390 | 7.15 | 10,200 |
| May 21 | do | 354 | 2,640 | 7.80 | 11,500 |
| May 21 | do | 354 | 2,680 | 7.90 | 11,800 |
| June 11 | do | 370 | 3,510 | 10.50 | 20,600 |
| June 18 | do | 360 | 3,000 | 9.00 | 15,800 |
| June 26 | do | 369 | 2,770 | 8.35 | 13,200 |
| July 7 | do | 366 | 2,620 | 7.90 | 12,100 |
| July 16 | do | 354 | 1,730 | 5.40 | 5,340 |
| July 27 | do | 345 | 1,260 | 4.00 | 2,780 |
| August 8 | Sawyer and Martin | 248 | 854 | 2.68 | 1,350 |
| September 3 | W. F. Martin | 210 | 648 | 1.75 | 564 |
| November 26 | do | 205 | 620 | 1.64 | 476 |
| November 27 | R. S. Hawley | 206 | 569 | 1.45 | 402 |

*Daily gage height, in feet, of American River near Fairoaks, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.5 | 3.65 | 6.8 | 10.4 | 7.6 | 9.1 | 7.45 | 3.35 | 1.8 | 1.3 | 1.35 | 1.5 |
| 2 | 1.4 | 3.55 | 6.4 | 9.6 | 8.45 | 9.45 | 8.35 | 3.15 | 1.75 | 1.4 | 1.4 | 1.5 |
| 3 | 1.4 | 3.7 | 7.9 | 8.8 | 8.45 | 10.3 | 8.25 | 3.2 | 1.8 | 1.35 | 1.55 | 1.5 |
| 4 | 1.5 | 3.6 | 7.65 | 8.25 | 9.2 | 9.75 | 8.0 | 3.1 | 1.7 | 1.3 | 1.95 | 1.5 |
| 5 | 1.2 | 3.65 | 6.3 | 7.4 | 10.4 | 9.1 | 8.15 | 2.95 | 1.8 | 1.3 | 3.4 | 1.5 |
| 6 | 1.2 | 3.75 | 5.95 | 7.1 | 9.85 | 8.7 | 7.4 | 2.75 | 1.65 | 1.3 | 2.75 | 1.5 |
| 7 | 1.5 | 3.7 | 5.95 | 7.15 | 10.3 | 9.0 | 7.25 | 2.7 | 1.6 | 1.3 | 2.25 | 1.5 |
| 8 | 1.2 | 3.75 | 5.95 | 7.6 | 10.25 | 9.25 | 7.05 | 2.75 | 1.6 | 1.3 | 1.9 | 2.15 |
| 9 | 1.4 | 3.8 | 6.1 | 7.35 | 9.6 | 9.25 | 6.9 | 2.7 | 1.6 | 1.3 | 1.75 | 2.75 |
| 10 | 1.2 | 4.1 | 6.15 | 7.65 | 9.75 | 9.75 | 6.2 | 2.65 | 1.5 | 1.3 | 1.6 | 2.45 |
| 11 | 1.4 | 3.85 | 6.45 | ..... | 10.1 | 10.8 | 6.0 | 2.7 | 1.5 | 1.3 | 1.6 | 10.25 |
| 12 | 1.75 | 3.7 | 9.25 | ..... | 9.85 | 11.0 | 5.85 | 2.7 | 1.5 | 1.25 | 1.55 | 7.15 |
| 13 | 5.85 | 3.75 | 9.7 | 7.2 | 8.7 | 9.95 | 5.8 | 2.45 | 1.5 | 1.2 | 1.6 | 4.65 |
| 14 | 8.35 | 4.2 | 12.85 | 7.2 | 8.0 | 9.1 | 5.9 | 2.4 | 1.5 | 1.25 | 1.6 | 3.7 |
| 15 | 6.75 | 6.05 | 11.35 | 7.65 | 8.05 | 8.9 | 5.65 | 2.4 | 1.6 | 1.2 | 1.6 | 3.3 |

*Daily gage height, in feet, of American River near Fairoaks, Cal., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 9.3 | 6.05 | 8.85 | 8.0 | 7.75 | 9.8 | 5.45 | 2.25 | 1.7 | 1.2 | 1.7 | 2.85 |
| 17 | 10.55 | 6.0 | 8.3 | 8.0 | 7.5 | 9.85 | 5.3 | 2.2 | 1.6 | 1.25 | 1.8 | 2.65 |
| 18 | 15.45 | 5.3 | 6.65 | 8.1 | 7.7 | 9.45 | 5.0 | 2.15 | 1.5 | 1.2 | 1.7 | 2.55 |
| 19 | 15.5 | 8.35 | 6.2 | 7.85 | 7.35 | 8.25 | 4.8 | 2.1 | 1.5 | 1.25 | 1.6 | 2.5 |
| 20 | 9.85 | 6.6 | 6.0 | 7.7 | 7.25 | 8.8 | 4.6 | 2.1 | 1.4 | 1.3 | 1.6 | 2.45 |
| 21 | 6.85 | 9.35 | 6.0 | 7.6 | 7.7 | 9.7 | 4.6 | 2.1 | 1.4 | 1.3 | 1.6 | 2.4 |
| 22 | 6.25 | 8.35 | 8.1 | 8.2 | 7.6 | 10.25 | 4.4 | 2.15 | 1.3 | 1.3 | 1.6 | 2.8 |
| 23 | 5.2 | 7.0 | 9.95 | 8.7 | 7.4 | 10.25 | 4.35 | 2.1 | 1.3 | 1.3 | 1.6 | 3.65 |
| 24 | 5.05 | 6.65 | 13.35 | 8.5 | 7.15 | 9.4 | 4.35 | 2.0 | 1.3 | 1.3 | 1.6 | 3.55 |
| 25 | 4.9 | 7.0 | 12.65 | 7.95 | 7.1 | 8.35 | 4.4 | 2.0 | 1.35 | 1.3 | 1.6 | 5.7 |
| 26 | 4.4 | 6.5 | 12.00 | 7.65 | 9.75 | 8.1 | 4.35 | 1.85 | 1.3 | 1.3 | 1.6 | 9.95 |
| 27 | 4.05 | 6.5 | 10.45 | 8.3 | 9.7 | 7.1 | 4.15 | 1.9 | 1.35 | 1.3 | 1.5 | 9.45 |
| 28 | 4.25 | 7.8 | 9.15 | 8.45 | 11.75 | 6.85 | 3.95 | 1.7 | 1.4 | 1.35 | 1.5 | 6.25 |
| 29 | 4.0 | ..... | 7.85 | 8.2 | 11.25 | 6.85 | 3.95 | 1.7 | 1.3 | 1.4 | 1.5 | 5.15 |
| 30 | 3.7 | ..... | 8.45 | 7.6 | 8.85 | 6.65 | 3.7 | 1.7 | 1.35 | 1.35 | 1.5 | 5.5 |
| 31 | 3.65 | ..... | 9.25 | ..... | 8.6 | ..... | 3.5 | 1.75 | ..... | 1.4 | ..... | 5.8 |

*Rating table for American River near Fairoaks, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.20 | 300 | 2.30 | 910 | 3.40 | 1,980 | 5.00 | 4,380 | 8.00 | 12,100 |
| 1.30 | 340 | 2.40 | 990 | 3.50 | 2,090 | 5.20 | 4,780 | 9.00 | 15,380 |
| 1.40 | 380 | 2.50 | 1,070 | 3.60 | 2,200 | 5.40 | 5,180 | 10.00 | 18,980 |
| 1.50 | 420 | 2.60 | 1,160 | 3.70 | 2,310 | 5.60 | 5,600 | 11.00 | 22,900 |
| 1.60 | 470 | 2.70 | 1,250 | 3.80 | 2,420 | 5.80 | 6,040 | 12.00 | 27,100 |
| 1.70 | 520 | 2.80 | 1,350 | 3.90 | 2,540 | 6.00 | 6,540 | 13.00 | 31,300 |
| 1.80 | 570 | 2.90 | 1,450 | 4.00 | 2,660 | 6.20 | 7,060 | 14.00 | 35,500 |
| 1.90 | 630 | 3.00 | 1,550 | 4.20 | 2,920 | 6.40 | 7,580 | 15.00 | 39,700 |
| 2.00 | 690 | 3.10 | 1,650 | 4.40 | 3,260 | 6.60 | 8,100 | 16.00 | 43,900 |
| 2.10 | 760 | 3.20 | 1,760 | 4.60 | 3,620 | 6.80 | 8,620 | | |
| 2.20 | 830 | 3.30 | 1,870 | 4.80 | 3,980 | 7.00 | 9,140 | | |

NOTE.—This table is based on 19 discharge measurements made during 1906, and is well defined between gage heights 1.4 feet and 10.5 feet.

*Monthly discharge of American River near Fairoaks, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum | Minimum. | Mean. | |
| January | 41,800 | 300 | 7,010 | 431,000 |
| February | 16,600 | 2,140 | 5,830 | 324,000 |
| March | 32,800 | 6,410 | 13,900 | 855,000 |
| April | 20,500 | 9,420 | [a] 12,100 | 720,000 |
| May | 26,000 | 9,420 | 15,000 | 922,000 |
| June | 22,900 | 8,230 | 15,900 | 946,000 |
| July | 13,200 | 2,090 | 6,180 | 380,000 |
| August | 1,920 | 520 | 1,010 | 62,100 |
| September | 570 | 340 | 433 | 25,800 |
| October | 380 | 300 | 338 | 20,800 |
| November | 1,980 | 360 | 567 | 33,700 |
| December | 19,900 | 420 | 3,900 | 240,000 |
| The year | 41,800 | 300 | 6,850 | 4,960,000 |

[a] Discharge for April 11 and 12 interpolated.

NOTE.—These values are excellent.

## SAN JOAQUIN RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

San Joaquin River is divided into two distinct parts. The valley portion forms the central drainage line of the San Joaquin Valley, and during the spring is navigable for 100 miles or more. Stanislaus, Tuolumne, Merced, and Kings rivers are the largest streams in this portion of the drainage basin. The waters of Kings, Kaweah, Tule, and Kern rivers, which are located in the portion of the San Joaquin Valley south and east of Fresno, although forming a portion of the drainage of San Joaquin River, seldom reach this stream, their entire flow, except in extreme flood, being diverted and used for irrigation at points where they emerge from the foothills. The valley is fertile and almost destitute of timber. The mountainous portion of the stream drains the western slope of the Sierra Nevada between Merced River on the north and Kings River on the south, the crest of its divide reaching an elevation of 13,000 feet in Mount Lyell and an elevation of 14,000 feet in Mount Goddard. There are numerous tributaries in this portion of the drainage basin, many of which have their source in the high elevations. The formation is of granite, which in the upper reaches is bare and sharply marked by glacial action. The middle reaches of the basin are well timbered, the timber diminishing on the lower foothills, which have a covering of brush and grass. The precipitation takes the form of snow on the higher elevations. The fall of the river is rapid, with many favorable locations for power development. There are numerous lakes in the upper reaches of the basin. A storage reservoir has been constructed on North Fork, which will tend to further regulate the flow of the river.

### MAIN SAN JOAQUIN RIVER.

#### SAN JOAQUIN RIVER AT HERNDON, CAL.

The gage rod at this station was established by the engineering department of the Southern Pacific Railroad Company in 1879. The old trestle bridge was torn down by the railroad company during 1899 and a new iron structure was erected in its place. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 184, where are given also references to publications that contain data for previous years.

*Daily gage height, in feet, of San Joaquin River at Herndon, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.65 | 3.25 | 4.2 | 8.5 | 6.4 | 8.4 | 10.5 | 8.2 | 4.35 | 3.2 | 3.0 | 2.6 |
| 2 | 2.65 | 3.25 | 3.75 | 7.0 | 6.75 | 8.25 | 11.25 | 7.65 | 4.35 | 3.2 | 3.0 | 2.6 |
| 3 | 2.65 | 3.1 | 3.75 | 6.65 | 7.5 | 8.5 | 11.4 | 7.2 | 4.35 | 3.2 | 3.0 | 2.6 |
| 4 | 2.65 | 3.1 | 5.6 | 6.5 | 8.35 | 8.75 | 12.5 | 7.0 | 4.25 | 3.2 | 3.0 | 2.5 |
| 5 | 2.65 | 3.1 | 4.5 | 6.35 | 8.5 | 8.65 | 12.25 | 7.0 | 4.25 | 3.2 | 3.0 | 2.5 |
| 6 | 2.65 | 3.1 | 4.25 | 5.75 | 9.4 | 9.35 | 12.0 | 7.0 | 4.25 | 3.2 | 3.0 | 2.5 |
| 7 | 2.65 | 3.1 | 4.1 | 5.65 | 9.65 | 8.5 | 12.0 | 6.65 | 4.2 | 3.1 | 3.0 | 2.5 |
| 8 | 2.65 | 3.1 | 4.0 | 5.65 | 10.0 | 9.0 | 11.75 | 6.6 | 4.2 | 3.1 | 3.0 | 2.5 |
| 9 | 2.65 | 3.1 | 4.2 | 6.0 | 9.75 | 10.25 | 11.65 | 6.6 | 4.2 | 3.1 | 3.0 | 2.5 |
| 10 | 2.65 | 3.0 | 4.25 | 6.5 | 11.0 | 11.0 | 11.0 | 6.4 | 4.0 | 3.1 | 3.0 | 2.5 |
| 11 | 2.65 | 3.0 | 4.25 | 7.35 | 12.35 | 11.5 | 10.65 | 6.25 | 4.0 | 3.1 | 3.0 | 2.5 |
| 12 | 2.65 | 3.0 | 6.75 | 6.65 | 12.0 | 12.5 | 11.0 | 6.25 | 3.65 | 3.1 | 3.0 | 2.5 |
| 13 | 2.65 | 3.0 | 6.35 | 6.65 | 11.25 | 12.75 | 10.65 | 6.5 | 3.65 | 3.1 | 3.0 | 3.0 |
| 14 | 10.5 | 3.25 | 6.0 | 6.4 | 10.2 | 11.75 | 10.65 | 6.5 | 3.6 | 3.1 | 3.0 | 3.5 |
| 15 | 6.5 | 3.4 | 10.0 | 6.65 | 9.65 | 11.5 | 10.65 | 6.4 | 3.5 | 3.1 | 3.0 | 3.25 |
| 16 | 4.9 | 3.4 | 8.5 | 6.65 | 9.0 | 12.0 | 10.5 | 6.2 | 3.5 | 3.1 | 3.0 | 3.25 |
| 17 | 4.0 | 3.65 | 7.2 | 6.65 | 9.25 | 13.0 | 10.5 | 6.2 | 3.5 | 3.1 | 3.0 | 3.1 |
| 18 | 4.0 | 4.2 | 7.0 | 7.0 | 9.5 | 12.0 | 10.5 | 6.1 | 3.4 | 3.0 | 3.0 | 3.0 |
| 19 | 13.0 | 4.2 | 6.0 | 7.5 | 10.4 | 12.35 | 10.0 | 6.1 | 3.4 | 3.0 | 3.0 | 3.0 |
| 20 | 9.0 | 4.1 | 6.0 | 8.2 | 10.5 | 13.2 | 9.65 | 6.0 | 3.35 | 3.0 | 3.0 | 3.0 |
| 21 | 7.35 | 4.0 | 6.0 | 8.0 | 10.65 | 14.35 | 9.5 | 6.0 | 3.35 | 3.0 | 3.0 | 3.0 |
| 22 | 5.2 | 4.0 | 6.35 | 8.4 | 10.0 | 13.65 | 9.5 | 6.0 | 3.35 | 3.0 | 3.0 | 3.0 |
| 23 | 4.5 | 4.2 | 9.00 | 10.0 | 10.35 | 13.0 | 9.75 | 5.65 | 3.35 | 3.0 | 3.0 | 3.0 |
| 24 | 4.2 | 4.25 | 8.5 | 8.35 | 10.0 | 13.0 | 10.35 | 5.65 | 3.35 | 3.0 | 3.0 | 3.0 |
| 25 | 4.0 | 4.25 | 8.4 | 7.75 | 9.35 | 12.65 | 10.0 | 5.5 | 3.2 | 3.0 | 3.0 | 3.0 |
| 26 | 4.0 | 4.2 | 8.0 | 7.75 | 9.75 | 12.35 | 10.0 | 5.5 | 3.2 | 3.0 | 3.0 | 3.5 |
| 27 | 4.0 | 4.2 | 7.5 | 7.65 | 10.65 | 11.2 | 9.65 | 5.35 | 3.2 | 3.0 | 3.0 | 3.65 |
| 28 | 4.0 | 4.2 | 7.2 | 8.0 | 11.6 | 11.0 | 9.5 | 5.0 | 3.2 | 3.0 | 3.0 | 3.65 |
| 29 | 3.75 | ..... | 6.5 | 7.75 | 10.35 | 10.35 | 9.0 | 4.65 | 3.2 | 3.0 | 2.85 | 3.75 |
| 30 | 3.5 | ..... | 7.35 | 6.75 | 10.0 | 10.0 | 8.5 | 4.5 | 3.2 | 3.0 | 2.6 | 3.75 |
| 31 | 3.4 | ..... | 8.25 | ..... | 9.65 | ..... | 8.25 | 4.5 | ..... | 3.0 | ..... | 3.75 |

NOTE.—Gage heights have been reduced to feet and tenths from feet and inches as furnished by the Southern Pacific Railroad Company.

## MISCELLANEOUS MEASUREMENT IN SAN JOAQUIN RIVER DRAINAGE BASIN.

The following measurement was made of San Joaquin River November 21, 1906, from the bridge at Polasky, Cal.:

Width, 133 feet; area, 194 square feet; discharge, 333 second-feet.

## KERN RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Kern River drains 2,345 square miles of the western slope of the Sierra Nevada at its extreme southern limits. This drainage basin is the largest of any stream discharging into the San Joaquin Valley, having an area 600 square miles greater than that of Kings River. It has its source in the highest elevations of the Sierra Nevada, draining the western and southern slopes of Mount Whitney and numerous other high granite peaks grouped about it, which reach elevations of over 14,000 feet. Its general direction is south for about 65 miles, when it turns and flows in a southwesterly direction, discharging into the San Joaquin Valley east of Bakersfield, Cal. Extending, as it

does in its upper reaches, for some distance parallel with the Sierra Nevada, it receives waters not only from the main crest on the east, but also from a somewhat lower divide on the west behind the basins of the Kaweah and Tule rivers. It has numerous tributaries, the principal ones, which drain the higher elevations of the main crest of the Sierra Nevada, entering from the east. The topography is extremely rough and broken in the upper reaches of this basin, becoming less rugged in the middle portion in the vicinity of Kernville, where there is quite an extensive valley with considerable cultivated land; below this point the stream enters a rough canyon, finally discharging into the flat country of the San Joaquin Valley. The entire flow, except during extreme flood stages, is diverted and used for irrigation at points where streams emerge from the foothills.

The formation is of granite, which, above the 10,000-foot contour, is practically bare of timber growth. Between elevations of 3,000 and 10,000 feet there is a good depth of soil, with timber and brush covering; the lower reaches have a light covering of brush and grass.

There are several lakes and marshes scattered throughout this basin, but they are less numerous than in the basins farther to the north. Several power plants are located on this stream, none of which, however, receive water from storage reservoirs, the diversions being made from the natural flow of the river and again returned to the river channel. The precipitation is very light throughout this basin, with the possible exception of the high elevations surrounding Mount Whitney, where the snow remains through the summer months.

### KERN RIVER NEAR BAKERSFIELD, CAL.

This station, established in 1893 by Walter James, chief engineer of the Kern County Land Company, is located at what is known as "first point of measurement," 5 miles above Bakersfield and at the mouth of the canyon of the river.

Regular meter measurements are taken, and an automatic gage records daily fluctuations of the river heights. A. K. Warren, the engineer in charge of this work for the Kern County Land Company, attends to the discharge measurements with accuracy and precision and furnishes the Geological Survey with the final results. Information in regard to this station is contained in Water-Supply Papers Nos. 81, 85, 100, 134, and 177 of the United States Geological Survey.

*Daily discharge, in second-feet, of Kern River near Bakersfield, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 242 | 529 | 854 | 2,980 | 2,846 | 5,416 | 7,369 | 3,552 | 1,522 | 697 | 546 | 518 |
| 2 | 253 | 513 | 806 | 2,651 | 2,798 | 5,353 | 7,765 | 3,282 | 1,438 | 705 | 570 | 517 |
| 3 | 230 | 506 | 779 | 2,424 | 2,986 | 5,306 | 8,251 | 3,236 | 1,369 | 695 | 566 | 542 |
| 4 | 233 | 509 | 795 | 2,291 | 3,337 | 5,495 | 8,431 | 3,147 | 1,297 | 677 | 554 | 575 |
| 5 | 241 | 529 | 842 | 2,172 | 3,786 | 5,964 | 8,246 | 2,953 | 1,255 | 680 | 550 | 545 |
| 6 | 246 | 538 | 777 | 2,051 | 4,434 | 6,126 | 8,129 | 2,905 | 1,201 | 687 | 580 | 506 |
| 7 | 253 | 560 | 765 | 2,010 | 4,608 | 5,788 | 7,973 | 2,880 | 1,167 | 622 | 555 | 530 |
| 8 | 256 | 580 | 755 | 1,970 | 5,278 | 5,932 | 7,729 | 2,852 | 1,111 | 618 | 528 | 552 |
| 9 | 260 | 646 | 785 | 2,135 | 6,097 | 6,311 | 7,607 | 2,769 | 1,064 | 634 | 539 | 587 |
| 10 | 265 | 578 | 851 | 2,296 | 6,782 | 6,797 | 7,257 | 2,627 | 1,039 | 639 | 516 | 676 |
| 11 | 269 | 589 | 896 | 2,302 | 6,624 | 7,213 | 7,176 | 2,536 | 1,030 | 645 | 499 | 675 |
| 12 | 267 | 610 | 1,026 | 2,278 | 6,133 | 8,190 | 7,211 | 2,548 | 983 | 647 | 502 | 654 |
| 13 | 272 | 568 | 1,996 | 2,336 | 5,687 | 8,829 | 7,072 | 2,473 | 938 | 649 | 518 | 677 |
| 14 | 1,626 | 538 | 1,945 | 2,484 | 5,640 | 9,079 | 6,705 | 2,377 | 919 | 631 | 520 | 653 |
| 15 | 1,828 | 574 | 1,716 | 2,635 | 5,886 | 9,072 | 6,628 | 2,276 | 916 | 612 | 529 | 601 |
| 16 | 1,293 | 684 | 5,264 | 2,767 | 6,079 | 9,142 | 6,719 | 2,211 | 891 | 613 | 514 | 589 |
| 17 | 890 | 701 | 5,527 | 2,898 | 6,055 | 9,004 | 6,603 | 2,215 | 883 | 592 | 462 | 587 |
| 18 | 687 | 661 | 3,025 | 3,032 | 6,348 | 8,819 | 6,254 | 2,206 | 883 | 564 | 446 | 584 |
| 19 | 1,370 | 646 | 2,106 | 3,178 | 6,868 | 8,993 | 6,093 | 2,097 | 839 | 554 | 476 | 562 |
| 20 | 2,554 | 655 | 1,807 | 3,343 | 7,339 | 9,375 | 5,870 | 2,215 | 807 | 555 | 468 | 556 |
| 21 | 1,145 | 717 | 1,725 | 3,597 | 7,443 | 9,505 | 5,439 | 2,192 | 809 | 564 | 433 | 552 |
| 22 | 931 | 785 | 1,854 | 3,911 | 7,381 | 9,505 | 4,997 | 2,071 | 806 | 560 | 450 | 560 |
| 23 | 807 | 739 | 1,978 | 4,135 | 7,025 | 9,311 | 5,648 | 1,840 | 788 | 558 | 474 | 556 |
| 24 | 746 | 681 | 2,284 | 4,255 | 6,492 | 9,107 | 5,920 | 1,662 | 785 | 564 | 462 | 550 |
| 25 | 698 | 665 | 3,417 | 3,853 | 6,184 | 8,948 | 5,595 | 1,540 | 781 | 559 | 440 | 562 |
| 26 | 666 | 710 | 3,983 | 3,698 | 7,660 | 8,668 | 5,347 | 1,446 | 777 | 562 | 446 | 592 |
| 27 | 643 | 735 | 4,150 | 3,598 | 7,832 | 8,187 | 5,392 | 1,405 | 755 | 568 | 478 | 948 |
| 28 | 616 | 773 | 3,195 | 3,692 | 7,420 | 7,529 | 5,269 | 1,435 | 731 | 557 | 479 | 914 |
| 29 | 602 | ..... | 2,701 | 3,347 | 6,825 | 7,143 | 4,659 | 1,467 | 715 | 553 | 487 | 802 |
| 30 | 551 | ..... | 2,527 | 2,973 | 6,102 | 7,010 | 4,311 | 1,434 | 704 | 564 | 502 | 732 |
| 31 | 548 | ..... | 2,818 | ..... | 5,646 | ..... | 3,925 | 1,431 | ..... | 565 | ..... | 697 |

*Monthly discharge of Kern River near Bakersfield, Cal., for 1906.*

[Drainage area, 2,345 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 2,554 | 230 | 693 | 42,600 | 0.296 | 0.34 |
| February | 785 | 506 | 626 | 34,800 | .267 | .28 |
| March | 5,527 | 755 | 2,063 | 127,000 | .880 | 1.01 |
| April | 4,255 | 1,970 | 2,910 | 173,000 | 1.24 | 1.38 |
| May | 7,832 | 2,798 | 5,859 | 360,000 | 2.50 | 2.88 |
| June | 9,505 | 5,306 | 7,704 | 458,000 | 3.29 | 3.67 |
| July | 8,431 | 3,925 | 6,503 | 400,000 | 2.77 | 3.19 |
| August | 3,552 | 1,405 | 2,299 | 141,000 | .980 | 1.13 |
| September | 1,522 | 704 | 973 | 57,900 | .415 | .46 |
| October | 705 | 553 | 609 | 37,400 | .260 | .30 |
| November | 580 | 433 | 503 | 29,900 | .215 | .24 |
| December | 948 | 506 | 618 | 38,000 | .264 | .30 |
| The year | 9,505 | 230 | 2,613 | 1,900,000 | 1.11 | 15.18 |

## TULE RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Tule River rises in the Sierra Nevada, and drains the country between Kaweah River on the north and Kern River on the south and east. Its drainage area is much less than that of Kaweah River,

although of the same general character. It has numerous small tributaries, few of which have their source at elevations above 8,000 feet. Its drainage basin does not extend back to the main divide, being cut off by Kern River, which reaches to the north and drains the higher portion of Sierra Nevada east of Tule River. There is good timber and brush covering on the higher and middle elevations, with grass and scattering timber on the lower elevations, where the soil is extensively cultivated. Below the gaging station the water is diverted by several canals and used for the irrigation of land in the vicinity of Portersville, where it is especially adapted for the raising of citrus fruits. During the flood period the water discharges through an old channel, and either sinks in the sand or finds its way to the old bed of Tulare Lake. The mean precipitation is probably not more than 20 inches, and falls principally in the form of rain.

### TULE RIVER NEAR PORTERSVILLE, CAL.

This station was established April 8, 1901. It is located about 8 miles east of Portersville, near the McFarland ranch, 100 feet below wagon bridge and about 1 mile above the mouth of South Fork of Tule River. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 189, where are given also references to publications that contain data for previous years.

*Discharge measurements of Tule River near Portersville, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 15 | C. H. Lee | 76 | 144 | 3.02 | 429 |
| March 28 | do | 83 | 206 | 4.42 | 1,210 |
| May 10 | do | 80 | 264 | 4.20 | 1,000 |
| May 24 | R. S. Hawley | 80 | 211 | 3.62 | 602 |
| May 26 | C. H. Lee | 159 | 607 | 6.75 | 2,950 |
| June 1 | do | 88 | 287 | 4.65 | 1,240 |
| June 8 | do | 84 | 251 | 4.10 | 909 |
| June 22 | R. S. Hawley | 86 | 278 | 4.40 | 1,090 |
| July 20 | do | 73 | 132 | 2.65 | 284 |
| July 26 | C. H. Lee | 69 | 112 | 2.30 | 222 |
| September 27 | R. S. Hawley | 59 | 46 | 1.40 | 56 |
| November 15 | do | 58 | 47 | 1.40 | 59 |
| November 24 | do | 58 | 47 | 1.44 | 62 |

*Daily gage height, in feet, of Tule River near Portersville, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.1 | 2.0 | 2.4 | 4.8 | 3.6 | 4.6 | 3.7 | 2.05 | 1.5 | 1.3 | 1.4 | 1.45 |
| 2 | 2.07 | 2.0 | 2.4 | 4.6 | 3.6 | 4.6 | 3.8 | 2.0 | 1.5 | 1.3 | 1.4 | 1.45 |
| 3 | 2.0 | 2.0 | 2.4 | 4.0 | 3.7 | 4.4 | 3.7 | 1.95 | 1.5 | 1.3 | 1.4 | 1.45 |
| 4 | 1.9 | 2.0 | 3.6 | 3.8 | 3.8 | 4.2 | 3.6 | 1.95 | 1.45 | 1.3 | 1.4 | 1.45 |
| 5 | 1.9 | 2.0 | 3.2 | 3.8 | 4.0 | 4.1 | 3.5 | 1.9 | 1.45 | 1.3 | 1.4 | 1.5 |
| 6 | 1.9 | 2.0 | 3.1 | 4.4 | 3.9 | 4.0 | 3.55 | 1.9 | 1.45 | 1.3 | 1.4 | 1.5 |
| 7 | 1.87 | 2.0 | 3.0 | 4.0 | 3.9 | 4.0 | 3.5 | 1.85 | 1.45 | 1.3 | 1.4 | 1.5 |
| 8 | 1.85 | 2.2 | 2.9 | 3.6 | 4.1 | 4.1 | 3.2 | 1.85 | 1.45 | 1.3 | 1.4 | 1.6 |
| 9 | 1.83 | 2.15 | 2.8 | 3.6 | 4.1 | 4.2 | 3.2 | 1.8 | 1.4 | 1.3 | 1.4 | 1.65 |
| 10 | 1.8 | 2.1 | 2.7 | 3.8 | 4.4 | 4.3 | 3.15 | 1.8 | 1.4 | 1.3 | 1.4 | 2.0 |

*Daily gage height, in feet, of Tule River near Portersville, Cal., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 1.8 | 2.05 | 2.7 | 3.8 | 4.4 | 4.4 | 3.1 | 1.8 | 1.4 | 1.3 | 1.4 | 2.6 |
| 12 | 2.0 | 2.0 | 6.6 | 3.6 | 4.5 | 4.5 | 3.0 | 1.75 | 1.4 | 1.3 | 1.4 | 2.4 |
| 13 | 5.65 | 2.0 | 5.7 | 3.6 | 4.25 | 4.4 | 2.9 | 1.7 | 1.4 | 1.3 | 1.4 | 2.0 |
| 14 | 7.35 | 2.0 | 4.2 | 3.6 | 4.0 | 4.3 | 2.85 | 1.7 | 1.4 | 1.3 | 1.4 | 1.8 |
| 15 | 3.85 | 3.1 | 8.35 | 3.6 | 4.0 | 4.35 | 2.8 | 1.65 | 1.4 | 1.3 | 1.4 | 1.5 |
| 16 | 3.3 | 2.8 | 8.5 | 3.6 | 4.1 | 4.3 | 2.75 | 1.65 | 1.4 | 1.3 | 1.4 | 1.65 |
| 17 | 3.0 | 2.7 | 7.0 | 3.6 | 4.1 | 4.35 | 2.75 | 1.6 | 1.4 | 1.3 | 1.4 | 1.65 |
| 18 | 2.8 | 2.6 | 5.0 | 3.6 | 4.1 | 4.3 | 2.7 | 1.6 | 1.35 | 1.3 | 1.4 | 1.65 |
| 19 | 7.0 | 2.5 | 4.5 | 3.6 | 4.1 | 4.35 | 2.7 | 1.6 | 1.35 | 1.3 | 1.4 | 1.65 |
| 20 | 4.1 | 2.5 | 4.2 | 3.7 | 4.0 | 4.25 | 2.65 | 1.55 | 1.35 | 1.3 | 1.45 | 1.65 |
| 21 | 3.3 | 2.7 | 4.2 | 3.8 | 3.9 | 4.3 | 2.6 | 1.55 | 1.35 | 1.3 | 1.45 | 1.65 |
| 22 | 2.9 | 2.65 | 4.2 | 4.0 | 3.8 | 4.4 | 2.5 | 1.55 | 1.35 | 1.3 | 1.45 | 1.65 |
| 23 | 2.7 | 2.6 | 4.2 | 4.25 | 3.7 | 4.3 | 2.45 | 1.55 | 1.35 | 1.35 | 1.45 | 1.65 |
| 24 | 2.5 | 2.5 | 5.4 | 4.0 | 3.65 | 4.2 | 2.4 | 1.55 | 1.4 | 1.35 | 1.45 | 1.65 |
| 25 | 2.4 | 2.45 | 6.0 | 3.7 | 3.6 | 4.0 | 2.35 | 1.55 | 1.45 | 1.35 | 1.45 | 1.65 |
| 26 | 2.3 | 2.4 | 7.25 | 3.6 | 6.4 | 3.95 | 2.3 | 1.55 | 1.4 | 1.35 | 1.45 | 2.3 |
| 27 | 2.2 | 2.4 | 5.2 | 3.4 | 6.55 | 3.9 | 2.25 | 1.5 | 1.4 | 1.35 | 1.45 | 2.1 |
| 28 | 2.15 | 2.4 | 4.5 | 4.6 | 6.5 | 3.7 | 2.25 | 1.5 | 1.35 | 1.35 | 1.45 | 2.0 |
| 29 | 2.1 | ..... | 4.3 | 3.8 | 5.4 | 3.7 | 2.2 | 1.5 | 1.35 | 1.35 | 1.45 | 1.95 |
| 30 | 2.05 | ..... | 4.3 | 3.7 | 5.0 | 3.7 | 2.15 | 1.5 | 1.3 | 1.35 | 1.45 | 1.9 |
| 31 | 2.03 | ..... | 5.4 | ..... | 4.7 | ..... | 2.1 | 1.5 | ..... | 1.35 | ..... | 1.9 |

*Rating table for Tule River near Portersville, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.30 | 37 | 2.20 | 170 | 3.10 | 420 | 4.00 | 840 | 5.80 | 2,140 |
| 1.40 | 47 | 2.30 | 190 | 3.20 | 460 | 4.20 | 960 | 6.00 | 2,300 |
| 1.50 | 58 | 2.40 | 210 | 3.30 | 500 | 4.40 | 1,090 | 6.20 | 2,460 |
| 1.60 | 70 | 2.50 | 235 | 3.40 | 540 | 4.60 | 1,230 | 6.40 | 2,640 |
| 1.70 | 83 | 2.60 | 260 | 3.50 | 580 | 4.80 | 1,370 | 6.60 | 2,820 |
| 1.80 | 98 | 2.70 | 285 | 3.60 | 630 | 5.00 | 1,510 | 6.80 | 3,000 |
| 1.90 | 115 | 2.80 | 315 | 3.70 | 680 | 5.20 | 1,660 | 7.00 | 3,180 |
| 2.00 | 132 | 2.90 | 345 | 3.80 | 730 | 5.40 | 1,820 | 8.00 | 4,080 |
| 2.10 | 150 | 3.00 | 380 | 3.90 | 780 | 5.60 | 1,980 | 9.00 | 4,980 |

NOTE.—This table is based on discharge measurements made during 1904–1906, and is well defined between gage heights 2.2 feet and 6.7 feet.

*Monthly discharge of Tule River near Portersville, Cal., for 1906.*

[Drainage area, 437 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 3,500 | 98 | 500 | 30,700 | 1.14 | 1.31 |
| February | 420 | 132 | 200 | 11,100 | .458 | .48 |
| March | 4,530 | 210 | 1,370 | 84,200 | 3.14 | 3.62 |
| April | 1,370 | 540 | 772 | 45,900 | 1.77 | 1.98 |
| May | 2,780 | 630 | 1,080 | 66,400 | 2.47 | 2.85 |
| June | 1,230 | 680 | 972 | 57,800 | 2.22 | 2.48 |
| July | 730 | 150 | 362 | 22,200 | .828 | .95 |
| August | 141 | 58 | 84.3 | 5,180 | .193 | .22 |
| September | 58 | 37 | 47.4 | 2,820 | .108 | .12 |
| October | 42 | 37 | 38.5 | 2,370 | .088 | .10 |
| November | 52 | 47 | 48.8 | 2,900 | .112 | .12 |
| December | 260 | 52 | 97.1 | 5,970 | .222 | .26 |
| The year | 4,530 | 37 | 464 | 338,000 | 1.06 | 14.49 |

NOTE.—Values are rated as follows: January, February, and July, good; March to June, excellent; August to December, fair.

### MISCELLANEOUS MEASUREMENTS IN THE TULE RIVER DRAINAGE BASIN.

The following miscellaneous measurements were made on South Fork of Tule River at a point one-half mile above the junction of South Fork with main Tule River:

May 26: Width, 40 feet; area, 100 square feet; discharge, 644 second-feet.
July 26: Width, 25 feet; area, 35 square feet; discharge, 64 second-feet.

## KAWEAH RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Kaweah River drains the western slope of the Sierra Nevada between the basins of Kings River on the north and Kern and Tule rivers on the south. This is an important stream, but its watershed is only about one-third that of Kings River and is much less elevated and snow covered than those of the Kings and Kern rivers. It has a number of tributaries which have their sources in numerous lakes and meadows on the higher elevations. The formation is of granite and similar in every way to that in the Kings River basin. The greater part of the area of 619 square miles above the gaging station is well covered with brush and timber. In this basin is situated the Sequoia National Park, where the largest grove of big trees (*Sequoia gigantea*) of the Sierra Nevada is found. Two power plants on this stream owned by the Mount Whitney Power Company, divert water from Middle and East forks. By building low dams at the outlet of some of the larger lakes, in the upper reaches of the basin, this company has constructed several small reservoirs, in which the water held back for use during the low-water flow of the stream, and is of great benefit to irrigators in the valley during the late summer months. About 6 miles below the gaging station the river leaves the foothills and flows across San Joaquin Valley in a general southwesterly direction to the old bed of Tulare Lake. After it leaves the foothills many canals divert water for the purpose of irrigating land in Tulare County, which is especially adapted to the raising of fruits.

The mean annual precipitation in the basin above the gaging station is from 20 to 40 inches, which falls in the form of snow over probably one-half the area.

### KAWEAH RIVER BELOW THREE RIVERS, CAL.

This station was established April 29, 1903. It is located at a point three-fourths of a mile below the confluence of the North, Middle, and South forks, 10 miles from the Southern Pacific Railroad station at Lemon Cove, Tulare County, Cal., and one-fourth mile west of the wagon road from Exeter to Three Rivers. The conditions

at this station and the bench marks are described in Water-Supply Paper No. 177, page 192, where are given also references to publications that contain data for previous years.

*Discharge measurements of Kaweah River below Three Rivers, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 16 | C. H. Lee | 156 | 491 | 6.00 | 644 |
| March 29 | do | 174 | 653 | 7.35 | 2,090 |
| May 11 | do | 183 | 888 | 8.35 | 3,780 |
| May 23 | R. S. Hawley | 180 | 814 | 7.80 | 2,690 |
| May 28 | C. H. Lee | 200 | 1,050 | 9.20 | 5,280 |
| May 31 | do | 182 | 837 | 8.00 | 3,180 |
| June 9 | do | 186 | 896 | 8.40 | 3,640 |
| June 20 | R. S. Hawley | 200 | 1,050 | 9.10 | 5,680 |
| June 20 | do | 198 | 1,010 | 8.95 | 5,290 |
| June 21 | do | 202 | 1,080 | 9.25 | 5,930 |
| June 29 | do | 185 | 896 | 8.25 | 3,470 |
| July 19 | do | 179 | 793 | 7.65 | 2,480 |
| July 28 | C. H. Lee | 170 | 676 | 7.10 | 1,700 |
| September 26 | R. S. Hawley | 146 | 332 | 4.97 | 148 |
| November 14 | do | 142 | 293 | 4.72 | 98 |

*Daily gage height, in feet, of Kaweah River below Three Rivers, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.55 | 5.3 | 5.85 | 7.8 | 6.95 | 8.05 | 8.8 | 6.65 | 5.5 | 4.9 | 4.7 | 4.8 |
| 2 | 4.5 | 5.3 | 5.75 | 7.6 | 7.05 | 8.0 | 9.1 | 6.8 | 5.45 | 4.9 | 4.7 | 4.8 |
| 3 | 4.6 | 5.3 | 5.85 | 7.4 | 7.2 | 8.15 | 9.1 | ..... | 5.4 | 4.9 | 4.7 | 4.8 |
| 4 | 4.6 | 5.3 | 6.45 | 7.3 | 7.45 | 8.1 | 9.05 | 6.4 | 5.4 | 4.9 | 4.75 | 5.0 |
| 5 | 4.6 | 5.3 | 5.95 | 7.05 | 7.6 | 8.25 | 9.0 | 6.5 | 5.35 | 4.9 | 5.05 | 4.9 |
| 6 | 4.6 | 5.3 | 5.95 | 7.1 | 7.55 | 8.0 | 9.0 | 6.45 | 5.3 | 4.85 | 4.85 | 4.9 |
| 7 | 4.6 | 5.3 | 5.95 | 6.95 | 7.8 | 7.95 | 8.8 | 6.45 | 5.25 | 4.8 | 4.8 | 4.9 |
| 8 | 4.6 | 5.4 | 6.0 | 6.9 | 8.2 | 8.3 | 8.8 | 6.4 | 5.3 | 4.8 | 4.8 | 4.9 |
| 9 | 4.6 | 5.45 | 6.0 | 7.0 | 8.35 | 8.65 | 8.6 | 6.4 | 5.3 | 4.8 | 4.75 | 5.3 |
| 10 | 4.6 | 5.4 | 6.05 | 7.35 | 8.35 | 8.85 | 8.55 | 6.3 | 5.3 | 4.75 | 4.75 | 5.1 |
| 11 | 4.6 | 5.4 | 6.05 | 7.1 | 8.25 | 9.1 | 8.5 | 6.3 | 5.25 | 4.75 | 4.7 | 5.0 |
| 12 | 4.7 | 5.35 | 9.3 | 6.95 | 8.0 | 9.25 | 8.5 | 6.2 | 5.2 | 4.75 | 4.7 | 5.7 |
| 13 | 8.1 | 5.3 | 7.9 | 7.0 | 7.75 | 9.1 | 8.4 | 6.15 | 5.1 | 4.75 | 4.7 | 5.25 |
| 14 | 9.25 | 5.4 | 7.05 | 7.05 | 7.8 | 9.1 | 8.4 | 6.1 | 5.15 | 4.7 | 4.7 | 5.1 |
| 15 | 6.55 | 6.3 | 10.3 | 7.05 | 7.75 | 9.1 | 8.35 | 6.1 | 5.15 | 4.7 | 4.7 | 5.1 |
| 16 | 5.95 | 6.0 | 10.1 | 7.15 | 7.9 | 9.25 | 8.3 | 6.1 | 5.2 | 4.7 | 4.7 | 5.0 |
| 17 | 5.7 | 5.8 | 8.75 | 7.15 | 8.15 | 9.1 | 8.2 | 6.0 | 5.1 | 4.7 | 4.7 | 5.0 |
| 18 | 6.3 | 5.7 | 7.85 | 7.15 | 8.3 | 9.1 | 7.95 | 6.0 | 5.05 | 4.7 | 4.7 | 5.0 |
| 19 | 9.3 | 5.7 | 7.35 | 7.25 | 8.35 | 9.45 | 7.8 | 6.0 | 5.0 | 4.7 | 4.7 | 4.95 |
| 20 | 6.7 | 5.7 | 7.15 | 7.45 | 8.3 | 9.4 | 7.7 | 5.9 | 5.0 | 4.7 | 4.7 | 4.95 |
| 21 | 6.15 | 6.25 | 7.25 | 7.6 | 8.2 | 9.5 | 7.6 | 5.8 | 5.0 | 4.7 | 4.7 | 4.95 |
| 22 | 5.85 | 5.9 | 7.15 | 7.6 | 8.1 | 9.35 | 7.75 | 5.75 | 5.0 | 4.7 | 4.7 | 5.0 |
| 23 | 5.7 | 5.75 | 7.05 | 7.8 | 7.75 | 9.35 | 7.85 | 5.65 | 4.95 | 4.7 | 4.75 | 5.0 |
| 24 | 5.6 | 5.7 | 8.05 | 7.45 | 7.6 | 9.35 | 7.7 | 5.6 | 5.0 | 4.7 | 4.75 | 5.0 |
| 25 | 5.6 | 5.7 | 8.7 | 7.25 | 8.05 | 9.15 | 7.6 | 5.6 | 5.0 | 4.7 | 4.75 | 5.0 |
| 26 | 5.5 | 5.7 | 8.6 | 7.15 | 9.45 | 8.9 | 7.6 | 5.55 | 4.95 | 4.7 | 4.8 | 6.5 |
| 27 | 5.5 | 5.7 | 8.2 | 7.35 | 8.5 | 8.55 | 7.5 | 5.5 | 4.9 | 4.7 | 4.75 | 5.75 |
| 28 | 5.4 | 6.15 | 7.95 | 7.45 | 9.75 | 8.4 | 7.4 | 5.5 | 4.9 | 4.7 | 4.75 | 5.8 |
| 29 | 5.4 | ..... | 7.4 | 7.15 | 8.45 | 8.45 | 7.05 | 5.5 | 4.9 | 4.65 | 4.8 | 5.4 |
| 30 | 5.4 | ..... | 7.65 | 7.0 | 8.2 | 8.65 | 6.9 | 5.5 | 4.9 | 4.65 | 4.7 | 5.3 |
| 31 | 5.3 | ..... | 8.35 | ..... | 8.1 | ..... | 6.8 | 5.6 | ..... | 4.7 | ..... | 5.45 |

*Rating table for Kaweah River below Three Rivers, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 4.50 | 75 | 5.40 | 312 | 6.30 | 840 | 7.20 | 1,830 | 8.20 | 3,420 |
| 4.60 | 91 | 5.50 | 350 | 6.40 | 930 | 7.30 | 1,960 | 8.40 | 3,800 |
| 4.70 | 109 | 5.60 | 395 | 6.50 | 1,020 | 7.40 | 2,100 | 8.60 | 4,180 |
| 4.80 | 130 | 5.70 | 445 | 6.60 | 1,120 | 7.50 | 2,240 | 8.80 | 4,590 |
| 4.90 | 154 | 5.80 | 500 | 6.70 | 1,220 | 7.60 | 2,400 | 9.00 | 5,040 |
| 5.00 | 180 | 5.90 | 560 | 6.80 | 1,340 | 7.70 | 2,560 | 9.20 | 5,520 |
| 5.10 | 210 | 6.00 | 625 | 6.90 | 1,460 | 7.80 | 2,720 | 9.40 | 6,000 |
| 5.20 | 240 | 6.10 | 690 | 7.00 | 1,580 | 7.90 | 2,880 | 9.60 | 6,480 |
| 5.30 | 274 | 6.20 | 760 | 7.10 | 1,700 | 8.00 | 3,060 | 9.80 | 6,960 |

NOTE.—This table is based upon 15 discharge measurements made during 1906 and is well defined below gage height 9.2 feet. Above gage height 9 feet the rating curve is a tangent, the difference being 240 per tenth.

*Monthly discharge of Kaweah River below Three Rivers, Cal., for 1906.*

[Drainage area, 520 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 5,760 | 75 | 784 | 48,200 | 1.51 | 1.74 |
| February | 840 | 274 | 418 | 23,200 | .804 | .84 |
| March | 8,160 | 472 | 2,440 | 150,000 | 4.69 | 5.41 |
| April | 2,720 | 1,460 | 1,910 | 114,000 | 3.67 | 4.10 |
| May | 6,840 | 1,520 | 3,210 | 197,000 | 6.17 | 7.11 |
| June | 6,240 | 2,970 | 4,670 | 278,000 | 8.98 | 10.02 |
| July | 5,280 | 1,340 | 3,430 | 211,000 | 6.60 | 7.61 |
| August | 1,340 | 350 | 691 | 42,500 | 1.33 | 1.53 |
| September | 350 | 154 | 226 | 13,400 | .435 | .49 |
| October | 154 | 100 | 120 | 7,380 | .231 | .27 |
| November | 195 | 109 | 119 | 7,080 | .229 | .26 |
| December | 1,020 | 109 | 245 | 15,100 | .471 | .54 |
| The year | 8,160 | 75 | 1,520 | 1,110,000 | 2.93 | 39.92 |

NOTE.—These values are excellent.

## KINGS RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Kings River rises on the western slope of the Sierra Nevada and drains the country located between San Joaquin River on the north and Kaweah and Kern rivers on the south. The Sierra Nevada at the head of this basin reaches elevations of over 14,000 feet and comprises the most rugged portion of the range; the sharp and precipitous peaks produce the grandest scenery to be found in the United States. The main tributaries of this stream flow through great canyons with high precipitous walls cut in the granite. The Kings River Canyon on South Fork and Tehipite Valley on Middle Fork rival the famed Yosemite Valley for grandeur of scenery. There are numerous tributaries, many of which have their sources in perpetual snow banks on the higher elevations. A large number of small lakes on the higher elevations are fed by small streams from perpetual snow banks or glaciers, and in them many of the tributaries have their source.

*A*. CABLE STATION, KINGS RIVER, NEAR RED MOUNTAIN, CALIFORNIA.

*B*. DISCHARGE MEASUREMENT BY WADING.

The formation is of granite, which above an elevation of 10,000 feet is bare, with scanty vegetation, being carved by the action of glaciers; below the 10,000-foot contour is a heavy covering of timber and underbrush. Extensive groves of big trees are scattered throughout this basin. On the lower elevations along the foothills the soil covering is light with a grass growth used for pasturage. Fully 80 per cent of the drainage area is now included in the boundaries of the Sierra Forest Reserve, which is patrolled for the prevention of fires and illegal herding. Below the gaging station, which is located at the point where the river leaves the foothills, canals divert the water for use in the valley lands of Fresno, Kings, and Tulare counties, where the climate and soil are especially adapted to the raising of grapes, fruits, etc., and the soil is under a high state of cultivation. During the period of flood discharge some water passes these canals and finds its way across Kings River delta in the natural channel to the old bed of Tulare Lake, which is now but an intermittent lake due largely to the diversion of water for irrigation purposes from the streams which drain into it. The drainage area above the Red Mountain gaging station is 1,742 square miles. The mean annual precipitation for this area varies from about 30 to 60 inches, which over a greater portion of the basin falls in the form of snow. The greater discharge of this stream is in the spring months when the snow is melting. (See Pl. III, *A*.)

### KINGS RIVER NEAR SANGER, CAL.

This station was established September 3, 1895. It is located 15 miles east of Sanger, Cal., near the mouth of the canyon, and is above all diversions. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 196, where are given also references to publications that contain data for previous years.

*Discharge measurements of Kings River near Sanger, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 30 | C. H. Lee | 164 | 564 | 5.20 | 966 |
| March 30 | do | 289 | 1,200 | 8.20 | 4,380 |
| May 12 | do | 320 | 2,060 | 10.80 | 10,500 |
| May 22 | R. S. Hawley | 320 | 2,190 | 11.15 | 12,600 |
| May 27 | C. H. Lee | 320 | 2,040 | 10.70 | 10,400 |
| June 2 | do | 312 | 1,800 | 9.90 | 8,200 |
| June 19 | R. S. Hawley | 358 | 2,880 | 13.10 | 21,600 |
| July 18 | do | 322 | 2,280 | 11.40 | 13,200 |
| July 27 | C. H. Lee | 317 | 2,240 | 11.20 | 11,800 |
| September 25 | R. S. Hawley | 172 | 496 | 5.18 | 768 |
| October 18 | do | 150 | 398 | 4.75 | 472 |
| November 13 | do | 149 | 375 | 4.63 | 398 |

*Daily gage height, in feet, of Kings River near Sanger, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.25 | 5.1 | 5.85 | 9.35 | 8.05 | 10.0 | 12.85 | 9.8 | 6.6 | 5.05 | 4.6 | 4.5 |
| 2 | 3.9 | 5.1 | 5.7 | 8.5 | 8.3 | 9.95 | 12.95 | 9.8 | 6.45 | 5.05 | 4.65 | 4.55 |
| 3 | 3.9 | 5.1 | 5.8 | 8.15 | 8.75 | 10.15 | 13.1 | 9.8 | 6.35 | 5.05 | 4.65 | 4.55 |
| 4 | 4.0 | 5.1 | 6.5 | 7.9 | 9.3 | 10.15 | 13.25 | 9.8 | 6.3 | 5.05 | 4.65 | 4.6 |
| 5 | 4.05 | 5.1 | 6.5 | 7.7 | 9.8 | 10.95 | 13.1 | 9.1 | 6.2 | 5.05 | 4.95 | 4.65 |
| 6 | 4.1 | 5.1 | 6.2 | 7.55 | 9.85 | 10.35 | 13.0 | 9.2 | 6.1 | 5.0 | 4.8 | 4.65 |
| 7 | 4.1 | 5.1 | 6.2 | 7.4 | 10.2 | 10.25 | 12.6 | 9.2 | 5.95 | 4.95 | 4.75 | 4.65 |
| 8 | ..... | 5.1 | 6.3 | 7.4 | 10.7 | 10.75 | 12.7 | 9.2 | 5.85 | 4.95 | 4.7 | 4.65 |
| 9 | 4.0 | 5.2 | 6.35 | 7.6 | 11.0 | 11.45 | 12.7 | 8.8 | 5.9 | 4.9 | 4.7 | 4.85 |
| 10 | 4.0 | 5.3 | 6.4 | 8.1 | 11.2 | 11.95 | 12.6 | 8.6 | 5.9 | 4.9 | 4.7 | 4.85 |
| 11 | 4.0 | 5.5 | 6.45 | 8.15 | 11.4 | 12.5 | 12.8 | 8.9 | 5.85 | 4.85 | 4.65 | 4.85 |
| 12 | 4.05 | 5.2 | 9.7 | 7.85 | 10.9 | 12.85 | 12.7 | 8.4 | 5.75 | 4.85 | 4.65 | 5.35 |
| 13 | 7.3 | 5.1 | 10.9 | 7.9 | 10.25 | 12.8 | 12.8 | 8.4 | 5.65 | 4.8 | 4.6 | 5.1 |
| 14 | 11.4 | 5.2 | 8.4 | 8.1 | 10.6 | 12.6 | 12.6 | 8.3 | 5.55 | 4.8 | 4.6 | 4.9 |
| 15 | 7.0 | 6.75 | 10.7 | 8.1 | 10.65 | 12.7 | 12.9 | 8.25 | 5.5 | 4.8 | 4.6 | 4.85 |
| 16 | 6.2 | 6.25 | 13.0 | 8.4 | 10.7 | 12.9 | 12.6 | 8.2 | 5.45 | 4.75 | 4.6 | 4.8 |
| 17 | 5.85 | 5.85 | 10.35 | 8.4 | 10.8 | 13.0 | 12.3 | 8.0 | 5.4 | 4.75 | 4.6 | 4.8 |
| 18 | 8.5 | 5.65 | 9.15 | 8.5 | 11.2 | 13.0 | 11.5 | 8.0 | 5.3 | 4.75 | 4.6 | 4.8 |
| 19 | 13.8 | 5.65 | 8.25 | 8.75 | 11.4 | 13.3 | 11.5 | 7.9 | 5.2 | 4.75 | 4.6 | 4.75 |
| 20 | 8.1 | 5.7 | 7.90 | 9.1 | 11.5 | 14.0 | 11.4 | 7.65 | 5.15 | 4.7 | 4.5 | 4.75 |
| 21 | 6.85 | 6.05 | 8.00 | 9.4 | 11.4 | 13.8 | 11.15 | 7.6 | 5.15 | 4.7 | 4.5 | 4.75 |
| 22 | 6.4 | 6.2 | 8.05 | 9.45 | 11.2 | 13.5 | 11.2 | 7.25 | 5.15 | 4.7 | 4.55 | 4.75 |
| 23 | 6.1 | 6.05 | 8.10 | 9.75 | 11.05 | 13.3 | 11.4 | 6.9 | 5.15 | 4.65 | 4.55 | 4.75 |
| 24 | 5.75 | 5.9 | 9.35 | 9.1 | 10.55 | 13.4 | 11.4 | 6.7 | 5.15 | 4.7 | 4.5 | 4.75 |
| 25 | 5.7 | 5.75 | 10.35 | 8.65 | 10.5 | 13.4 | 11.4 | 6.55 | 5.15 | 4.65 | 4.5 | 4.85 |
| 26 | 5.65 | 5.8 | 10.45 | 8.55 | 12.0 | 12.8 | 11.2 | 6.5 | 5.15 | 4.65 | 4.55 | 6.8 |
| 27 | 5.6 | 5.8 | 9.50 | 8.75 | 11.45 | 12.1 | 11.1 | 6.5 | 5.1 | 4.65 | 4.55 | 6.3 |
| 28 | 5.5 | 6.0 | 8.70 | 9.15 | 12.2 | 11.6 | 10.85 | 6.5 | 5.05 | 4.65 | 4.55 | 6.45 |
| 29 | 5.3 | ..... | 8.25 | 8.5 | 11.6 | 11.7 | 10.55 | 6.45 | 5.05 | 4.65 | 4.55 | 5.7 |
| 30 | 5.2 | ..... | 8.15 | 8.1 | 10.15 | 12.3 | 10.05 | 6.45 | 5.05 | 4.6 | 4.55 | 5.35 |
| 31 | 5.15 | ..... | 9.40 | ..... | 9.95 | ..... | 9.9 | 6.7 | ..... | 4.6 | ..... | 5.9 |

NOTE.—These gage heights were taken from an automatic river stage register, except June 15 to 30, when the instrument was out of use, and the readings are from the staff gage. The mean daily gage height is determined from the register sheets by the use of a planometer.

*Rating table for Kings River near Sanger, Cal.*

JANUARY 1 TO JUNE 30, 1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.90 | 205 | 5.00 | 740 | 6.10 | 1,550 | 7.40 | 2,965 | 9.60 | 7,360 |
| 4.00 | 240 | 5.10 | 805 | 6.20 | 1,640 | 7.60 | 3,240 | 9.80 | 7,900 |
| 4.10 | 280 | 5.20 | 870 | 6.30 | 1,730 | 7.80 | 3,535 | 10.00 | 8,470 |
| 4.20 | 325 | 5.30 | 940 | 6.40 | 1,820 | 8.00 | 3,850 | 11.00 | 11,700 |
| 4.30 | 370 | 5.40 | 1,010 | 6.50 | 1,920 | 8.20 | 4,190 | 12.00 | 15,900 |
| 4.40 | 420 | 5.50 | 1,085 | 6.60 | 2,020 | 8.40 | 4,570 | 13.00 | 21,040 |
| 4.50 | 470 | 5.60 | 1,160 | 6.70 | 2,120 | 8.60 | 4,980 | 14.00 | 26,600 |
| 4.60 | 520 | 5.70 | 1,235 | 6.80 | 2,230 | 8.80 | 5,410 | | |
| 4.70 | 570 | 5.80 | 1,310 | 6.90 | 2,340 | 9.00 | 5,860 | | |
| 4.80 | 625 | 5.90 | 1,390 | 7.00 | 2,460 | 9.20 | 6,330 | | |
| 4.90 | 680 | 6.00 | 1,470 | 7.20 | 2,705 | 9.40 | 6,840 | | |

JULY 1 TO DECEMBER 31, 1906.[b]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4.50 | 330 | 4.90 | 575 | 5.30 | 870 | 5.70 | 1,190 | 6.00 | 1,460 |
| 4.60 | 385 | 5.00 | 645 | 5.40 | 950 | 5.80 | 1,280 | 6.10 | 1,550 |
| 4.70 | 445 | 5.10 | 720 | 5.50 | 1,030 | 5.90 | 1,370 | | |
| 4.80 | 510 | 5.20 | 795 | 5.60 | 1,110 | | | | |

[a] This table is based on discharge measurements made during 1895–1906 and is well defined.
[b] This table is based on 3 discharge measurements made during 1906 and is well defined. Above gage height 6.1 feet it is the same as the previous table.

*Monthly discharge of Kings River near Sanger, Cal., for 1906.*

[Drainage area, 1,740 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 25,500 | 205 | 2,360 | 144,000 | 1.36 | 1.57 |
| February | 2,150 | 792 | 1,150 | 63,900 | 0.661 | .69 |
| March | 21,000 | 1,220 | 5,240 | 322,000 | 3.01 | 3.47 |
| April | 7,760 | 2,960 | 4,720 | 281,000 | 2.71 | 3.02 |
| May | 16,800 | 3,930 | 10,700 | 658,000 | 6.15 | 7.09 |
| June | 26,600 | 8,320 | 17,100 | 1,020,000 | 9.83 | 11.00 |
| July | 22,400 | 8,180 | 16,300 | 1,000,000 | 9.37 | 10.80 |
| August | 7,900 | 1,870 | 4,300 | 264,000 | 2.47 | 2.85 |
| September | 2,020 | 682 | 1,120 | 66,600 | 0.644 | .72 |
| October | 682 | 385 | 516 | 31,700 | 0.297 | .34 |
| November | 610 | 330 | 397 | 23,600 | 0.228 | .25 |
| December | 2,230 | 330 | 700 | 43,000 | 0.402 | .46 |
| The year | 26,600 | 205 | 5,380 | 3,920,000 | 3.09 | 42.26 |

NOTE.—Values are rated as excellent; discharges for September to December are based on 3 measurements which indicate a greater change in conditions of flow than had taken place in ten years previously, but they are believed to be accurate.

## MERCED RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Merced River drains that portion of the western slope of the Sierra Nevada located between Tuolumne River on the north and San Joaquin River on the south. Its drainage area is much less than that of Tuolumne River. It has numerous tributaries, several of which are of considerable size.

The topography of the country in this basin is similar to that of Tuolumne River, being rough and broken in the upper reaches. In this basin is situated the famous Yosemite Valley, with its precipitous walls and domes and great waterfalls, which occur on the main stream and its tributaries, which discharge into the valley over precipitous cliffs rising 2,000 to 3,000 feet above the floor of the valley. The formation is of granite, which on the upper reaches of the basin above Yosemite Valley is bare, rising in precipitous peaks and domes, and is smoothly marked by glacial action. The middle reaches of the basin are well timbered. The Mariposa grove of big trees is situated in the basin of the South Fork. The timber growth extends well down on the lower elevations to the foothills, where the covering is of brush and grass, used extensively for pasturage. Numerous lakes are scattered over the upper portion of the basin. The mean annual precipitation varies from 25 inches in the foothills to 60 inches on the higher elevations, where it falls in the form of snow, which melts in the spring months, except on the extreme higher mountain peaks, where it often remains during the entire year. After leaving the foothills at Merced Falls, where the gaging station is located, canals divert the water for irrigation on lands along the river bottom and in San Joaquin Valley. The surplus water during flood discharge enters San Joaquin River.

## MERCED RIVER ABOVE MERCED FALLS, CAL.

The measurement of Merced River was undertaken in response to numerous requests from mining and irrigation interests, the midsummer flow being less than the combined capacity of the irrigation and power canals taking water in the vicinity of Snelling. The station was established April 6, 1901. It is located 1 mile above Merced Falls. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 203, where are given also references to publications that contain data for previous years.

*Discharge measurements of Merced River above Merced Falls, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 27 | C. H. Lee | 143 | 380 | 9.40 | 710 |
| February 17 | do | 146 | 406 | 9.50 | 833 |
| March 31 | do | 321 | 1,900 | 14.80 | 12,700 |
| March 31 | do | 317 | 1,800 | 14.50 | 11,000 |
| April 1 | do | 305 | 1,360 | 13.20 | 7,680 |
| April 26 | R. S. Hawley | 268 | 760 | 11.42 | 3,000 |
| May 16 | C. H. Lee | 287 | 1,140 | 12.60 | 5,660 |
| May 27 | W. C. Sawyer | 301 | 1,270 | 13.15 | 6,960 |
| May 28 | do | 353 | 2,320 | 16.40 | 17,300 |
| May 28 | do | 350 | 2,270 | 16.20 | 16,000 |
| May 28 | do | 348 | 2,160 | 16.00 | 15,200 |
| May 28 | do | 347 | 2,160 | 15.90 | 14,900 |
| June 6 | do | 285 | 1,030 | 12.42 | 4,860 |
| June 16 | do | 318 | 1,640 | 14.50 | 11,000 |
| June 22 | do | 325 | 1,670 | 14.75 | 11,000 |
| June 30 | do | 306 | 1,240 | 13.48 | 7,270 |
| July 12 | do | 289 | 1,140 | 13.56 | 6,350 |
| July 13 | do | 303 | 1,210 | 13.68 | 6,980 |
| July 20 | do | 250 | 875 | 12.15 | 4,210 |
| July 21 | do | 247 | 846 | 11.85 | 4,040 |
| August 2 | do | 180 | 543 | 10.38 | 1,510 |
| August 4 | do | 180 | 522 | 10.30 | 1,430 |
| August 5 | do | 180 | 527 | 10.24 | 1,350 |
| August 19 | W. F. Martin | 168 | 428 | 9.85 | 917 |
| September 6 | do | 142 | 292 | 8.90 | 322 |
| November 20 | do | 130 | 224 | 8.42 | 145 |

*Daily gage height, in feet, of Merced River above Merced Falls, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8.1 | 9.0 | 10.35 | 13.05 | 11.35 | 12.4 | 14.0 | 10.55 | 9.1 | 8.35 | 8.3 | 8.4 |
| 2 | 8.1 | 9.0 | 10.15 | 12.15 | 11.55 | 12.45 | 14.2 | 10.5 | 9.1 | 8.35 | 8.3 | 8.35 |
| 3 | 8.05 | 9.0 | 10.05 | 11.7 | 11.75 | 12.65 | 14.35 | 10.45 | 9.0 | 8.4 | 8.3 | 8.35 |
| 4 | 8.0 | 9.0 | 11.3 | 11.45 | 12.15 | 12.65 | 14.35 | 10.35 | 9.0 | 8.4 | 8.3 | 8.3 |
| 5 | 8.0 | 9.0 | 10.7 | 11.25 | 12.45 | 13.15 | 14.3 | 10.25 | 8.95 | 8.45 | 8.5 | 8.4 |
| 6 | 8.05 | 9.0 | 10.5 | 11.0 | 12.75 | 12.55 | 14.15 | 10.15 | 8.9 | 8.4 | 8.7 | 8.35 |
| 7 | 8.05 | 9.0 | 10.2 | 11.0 | 13.0 | 12.25 | 14.05 | 10.15 | 8.9 | 8.35 | 8.55 | 8.3 |
| 8 | 8.0 | 9.0 | 10.15 | 10.85 | 13.15 | 12.7 | 14.05 | 10.15 | 8.9 | 8.4 | 8.5 | 8.35 |
| 9 | 8.05 | 9.05 | 10.1 | 10.95 | 13.2 | 13.1 | 13.9 | 10.15 | 8.9 | 8.4 | 8.45 | 8.4 |
| 10 | 8.15 | 9.1 | 10.1 | 11.25 | 13.5 | 13.35 | 13.5 | 10.15 | 8.8 | 8.4 | 8.4 | 8.5 |
| 11 | 8.05 | 9.25 | 10.15 | 11.45 | 13.85 | 13.95 | 13.55 | 10.3 | 8.8 | 8.4 | 8.4 | 9.75 |
| 12 | 8.15 | 9.1 | 13.25 | 11.15 | 13.35 | 14.4 | 13.6 | 10.15 | 8.75 | 8.3 | 8.4 | 11.65 |
| 13 | 10.55 | 9.0 | 12.8 | 11.05 | 12.75 | 14.65 | 13.4 | 9.95 | 8.8 | 8.3 | 8.4 | 9.6 |
| 14 | 13.45 | 9.05 | 11.7 | 11.15 | 12.75 | 14.0 | 13.3 | 9.9 | 8.75 | 8.3 | 8.4 | 9.05 |
| 15 | 10.55 | 9.95 | 16.7 | 11.15 | 12.8 | 14.05 | 13.05 | 9.8 | 8.75 | 8.3 | 8.4 | 8.9 |
| 16 | 10.3 | 9.9 | 13.55 | 11.3 | 12.7 | 14.4 | 12.8 | 9.75 | 8.7 | 8.3 | 8.4 | 8.8 |
| 17 | 10.8 | 9.5 | 12.2 | 11.35 | 12.6 | 14.7 | 12.65 | 9.75 | 8.7 | 8.3 | 8.4 | 8.75 |
| [illegible] | 13.85 | 9.4 | 11.5 | 11.3 | 12.95 | 14.15 | 12.4 | 9.65 | 8.6 | 8.35 | 8.3 | 8.65 |
| [illegible] | 16.9 | 9.75 | 11.1 | 11.45 | 13.3 | 14.55 | 12.2 | 9.8 | 8.6 | 8.35 | 8.4 | 8.65 |
| 20 | 11.55 | 9.65 | 10.85 | 11.6 | 13.3 | 14.8 | 11.85 | 9.85 | 8.5 | 8.3 | 8.4 | 8.65 |

*Daily gage height, in feet, of Merced River above Merced Falls, Cal., for 1906*—Cont'd.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 10.55 | 11.15 | 10.85 | 11.85 | 13.2 | 15.0 | 11.85 | 9.75 | 8.5 | 8.3 | 8.35 | 8.6 |
| 22 | 10.05 | 11.2 | 11.15 | 12.0 | 12.9 | 14.9 | 11.65 | 9.55 | 8.5 | 8.3 | 8.3 | 8.55 |
| 23 | 9.85 | 10.7 | 11.1 | 12.7 | 12.5 | 14.45 | 11.75 | 9.45 | 8.5 | 8.3 | 8.3 | 8.7 |
| 24 | 9.65 | 10.45 | 14.55 | 12.0 | 12.3 | 14.9 | 11.7 | 9.3 | 8.5 | 8.3 | 8.3 | 8.6 |
| 25 | 9.5 | 10.8 | 15.85 | 11.6 | 12.25 | 14.9 | 11.7 | 9.2 | 8.5 | 8.3 | 8.3 | 8.65 |
| 26 | 9.5 | 10.45 | 14.1 | 11.4 | 13.75 | 14.0 | 11.6 | 9.2 | 8.55 | 8.3 | 8.3 | 11.5 |
| 27 | 9.4 | 10.25 | 12.9 | 11.45 | 13.4 | 13.45 | 11.5 | 9.1 | 8.55 | 8.3 | 8.3 | 11.45 |
| 28 | 9.25 | 10.7 | 12.0 | 12.15 | 16.0 | 12.85 | 11.25 | 9.1 | 8.5 | 8.3 | 8.3 | 11.3 |
| 29 | 9.2 | ..... | 11.55 | 11.7 | 13.6 | 13.0 | 11.0 | 9.1 | 8.5 | 8.3 | 8.3 | 10.35 |
| 30 | 9.1 | ..... | 11.6 | 11.5 | 12.8 | 13.45 | 10.8 | 9.1 | 8.5 | 8.05 | 8.3 | 9.75 |
| 31 | 9.0 | ..... | 14.1 | ..... | 12.5 | ..... | 10.7 | 9.1 | ..... | 8.3 | ..... | 10.35 |

*Rating tables for Merced River above Merced Falls, Cal.*

JANUARY 1, 1905, TO JULY 31, 1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 8.00 | 90 | 9.00 | 465 | 10.00 | 1,240 | 11.00 | 2,545 | 13.00 | 6,630 |
| 8.10 | 115 | 9.10 | 520 | 10.10 | 1,315 | 11.20 | 2,870 | 13.20 | 7,130 |
| 8.20 | 140 | 9.20 | 580 | 10.20 | 1,455 | 11.40 | 3,215 | 13.40 | 7,630 |
| 8.30 | 170 | 9.30 | 645 | 10.30 | 1,570 | 11.60 | 3,570 | 13.60 | 8,150 |
| 8.40 | 200 | 9.40 | 715 | 10.40 | 1,690 | 11.80 | 3,945 | 13.80 | 8,670 |
| 8.50 | 235 | 9.50 | 790 | 10.50 | 1,820 | 12.00 | 4,340 | 14.00 | 9,200 |
| 8.60 | 275 | 9.60 | 870 | 10.60 | 1,955 | 12.20 | 4,755 | 15.00 | 12,050 |
| 8.70 | 315 | 9.70 | 955 | 10.70 | 2,095 | 12.40 | 5,200 | 16.00 | 15,300 |
| 8.80 | 360 | 9.80 | 1,045 | 10.80 | 2,240 | 12.60 | 5,665 | 17.00 | 18,800 |
| 8.90 | 410 | 9.90 | 1,140 | 10.90 | 2,390 | 12.80 | 6,140 | | |

AUGUST 1 TO DECEMBER 3, 1906.[b]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8.00 | 55 | 8.80 | 280 | 9.60 | 750 | 10.40 | 1,510 | 11.40 | 3,140 |
| 8.10 | 70 | 8.90 | 320 | 9.70 | 820 | 10.50 | 1,650 | 11.60 | 3,520 |
| 8.20 | 90 | 9.00 | 370 | 9.80 | 890 | 10.60 | 1,800 | 11.80 | 3,930 |
| 8.30 | 115 | 9.10 | 425 | 9.90 | 970 | 10.70 | 1,960 | 12.00 | 4,340 |
| 8.40 | 140 | 9.20 | 480 | 10.00 | 1,060 | 10.80 | 2,120 | | |
| 8.50 | 170 | 9.30 | 540 | 10.10 | 1,160 | 10.90 | 2,280 | | |
| 8.60 | 205 | 9.40 | 610 | 10.20 | 1,260 | 11.00 | 2,440 | | |
| 8.70 | 240 | 9.50 | 680 | 10.30 | 1,380 | 11.20 | 2,780 | | |

[a] This table is based on discharge measurements made during 1905–6 and is well defined.
[b] This table is based on 7 discharge measurements made during August to November, 1906, and is well defined above gage height 8.4 feet. Above gage height 12 feet, the table is the same as the previous one.

*Monthly discharge of Merced River above Merced Falls, Cal., for 1906.*

[Drainage area, 1,090 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 18,400 | 90 | 1,840 | 113,000 | 1.69 | 1.95 |
| February | 2,870 | 465 | 1,060 | 58,900 | .972 | 1.01 |
| March | 17,800 | 1,290 | 4,660 | 287,000 | 4.28 | 4.93 |
| April | 6,760 | 2,320 | 3,500 | 208,000 | 3.21 | 3.58 |
| May | 15,300 | 3,130 | 6,530 | 402,000 | 5.99 | 6.91 |
| June | 12,000 | 4,860 | 8,410 | 500,000 | 7.72 | 8.61 |
| July | 10,200 | 2,100 | 6,260 | 385,000 | 5.74 | 6.62 |
| August | 1,720 | 425 | 948 | 58,300 | .870 | 1.00 |
| September | 425 | 170 | 254 | 15,100 | .233 | .26 |
| October | 155 | 62 | 122 | 7,500 | .112 | .13 |
| November | 240 | 115 | 135 | 8,030 | .124 | .14 |
| December | 3,620 | 115 | 735 | 45,200 | .674 | .78 |
| The year | 18,400 | 62 | 2,870 | 2,090,000 | 2.63 | 35.92 |

NOTE.—These values are excellent.

## MERCED RIVER IN YOSEMITE VALLEY, CALIFORNIA.

This station was established July 11, 1904,. It is located at the wagon bridge, near the Sentinel Hotel. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 201, where are given also references to publications that contain data for previous years.

*Discharge measurements of Merced River in Yosemite Valley, California, in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 24 | W. B. Clapp | 95 | 668 | 6.80 | 1,760 |
| November 8 | C. W. Tucker | 89 | 286 | 3.30 | 50 |

*Daily gage height, in feet, of Merced River in Yosemite Valley, California, for 1906.*

| Day. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| 1 | | 6.0 | 9.4 | 6.2 | 4.3 | 3.5 | 3.3 | 3.2 |
| 2 | | 6.1 | 9.5 | 6.0 | 4.3 | 3.5 | 3.3 | 3.2 |
| 3 | | 6.75 | 9.8 | 6.0 | 4.2 | 3.6 | 3.3 | 3.2 |
| 4 | | 6.8 | 9.5 | 5.8 | 4.2 | 3.6 | 3.4 | 3.2 |
| 5 | | 7.4 | 9.6 | 5.7 | 4.1 | 3.5 | 3.5 | 3.2 |
| 6 | | 6.45 | 9.5 | 5.6 | 4.1 | 3.5 | 3.3 | 3.2 |
| 7 | | 6.5 | 9.5 | 5.6 | 4.1 | 3.6 | 3.3 | 3.2 |
| 8 | | 7.0 | 9.1 | 5.6 | 4.0 | 3.5 | 3.3 | 3.2 |
| 9 | | 7.8 | 9.1 | 5.6 | 4.0 | 3.5 | 3.3 | 3.2 |
| 10 | | 8.0 | 8.7 | 5.7 | 4.0 | 3.5 | 3.3 | 3.2 |
| 11 | | 9.55 | 8.6 | 5.8 | 4.0 | 3.4 | 3.3 | 3.2 |
| 12 | | 9.5 | 8.8 | 5.6 | 3.9 | 3.4 | 3.3 | ..... |
| 13 | | 9.6 | 9.0 | 5.4 | 3.9 | 3.5 | 3.3 | ..... |
| 14 | | 9.2 | 8.8 | 5.3 | 3.9 | 3.4 | 3.3 | ..... |
| 15 | | 9.1 | 8.3 | 5.2 | 3.9 | 3.4 | 3.3 | ..... |
| 16 | | 10.0 | 8.5 | 5.1 | 3.8 | 3.4 | 3.3 | ..... |
| 17 | | 9.5 | 8.3 | 5.1 | 3.7 | 3.3 | 3.3 | ..... |
| 18 | | 9.2 | 7.8 | 5.4 | 3.7 | 3.4 | 3.3 | ..... |
| 19 | | 9.8 | 7.7 | 5.5 | 3.6 | 3.3 | 3.3 | ..... |
| 20 | | 9.8 | 7.8 | 5.2 | 3.6 | 3.3 | 3.3 | ..... |
| 21 | | 10.0 | 7.7 | 4.9 | 3.5 | 3.3 | 3.3 | ..... |
| 22 | | 9.9 | 7.8 | 4.8 | 3.6 | 3.3 | 3.3 | ..... |
| 23 | 7.00 | 9.8 | 7.8 | 4.5 | 3.6 | 3.3 | 3.3 | ..... |
| 24 | 6.75 | 9.8 | 7.8 | 4.4 | 3.6 | 3.3 | 3.3 | ..... |
| 25 | 6.80 | 10.0 | 7.7 | 4.4 | 3.6 | 3.3 | 3.3 | ..... |
| 26 | 6.8 | 8.8 | 8.1 | 4.4 | 3.6 | 3.3 | 3.2 | ..... |
| 27 | 6.3 | 8.4 | 7.4 | 4.4 | 3.5 | 3.3 | 3.2 | ..... |
| 28 | 6.1 | 7.8 | 7.1 | 4.4 | 3.5 | 3.3 | 3.2 | ..... |
| 29 | 5.7 | 8.0 | 6.7 | 4.4 | 3.5 | 3.3 | 3.2 | ..... |
| 30 | 5.7 | 8.4 | 6.4 | 4.3 | 3.5 | 3.2 | 3.2 | ..... |
| 31 | 5.7 | ..... | 6.4 | 4.3 | ..... | 3.2 | ..... | ..... |

## YOSEMITE CREEK IN YOSEMITE VALLEY, CALIFORNIA.

This station was established July 9, 1904. It is located at the wagon bridge, about one-half mile from Yosemite, Cal. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 205, where are given also references to publications that contain data for previous years.

No measurements were made at this station during 1906. On November 12, with a gage height of 5 feet, there was no flow at the section.

*Daily gage height, in feet, of Yosemite Creek, in Yosemite Valley, Cal., for 1906.*

| Day. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| 1 | | 6.4 | 9.2 | 5.8 | 5.2 | 5.0 | 5.0 | 5.0 |
| 2 | | 6.5 | 9.5 | 5.7 | 5.2 | 5.0 | 5.0 | 5.0 |
| 3 | | 7.0 | 9.4 | 5.6 | 5.1 | 5.0 | 5.0 | 5.0 |
| 4 | | 7.1 | 9.4 | 5.6 | 5.1 | 5.0 | 5.2 | 5.0 |
| 5 | | 7.4 | 9.6 | 5.6 | 5.1 | 5.0 | 5.1 | 5.0 |
| 6 | | 7.0 | 9.5 | 5.5 | 5.1 | 5.0 | 5.1 | 5.0 |
| 7 | | 6.9 | 9.4 | 5.6 | 5.0 | 5.0 | 5.1 | 5.0 |
| 8 | | 7.1 | 9.2 | 5.5 | 5.0 | 5.0 | 5.0 | 5.0 |
| 9 | | 7.9 | 9.1 | 5.4 | 5.0 | 5.0 | 5.0 | 5.0 |
| 10 | | 8.0 | 8.8 | 5.5 | 5.0 | 5.0 | 5.0 | 5.0 |
| 11 | | 8.9 | 8.9 | 5.5 | 5.0 | 5.0 | 5.0 | 5.0 |
| 12 | | 9.8 | 8.0 | 5.4 | 5.0 | 5.0 | 5.0 | ..... |
| 13 | | 9.4 | 8.1 | 5.3 | 5.0 | 5.0 | 5.0 | ..... |
| 14 | | 8.8 | 8.0 | 5.4 | 5.0 | 5.0 | 5.0 | ..... |
| 15 | | 8.7 | 7.4 | 5.4 | 5.0 | 5.0 | 5.0 | ..... |
| 16 | | 11.15 | 7.2 | 5.3 | 5.0 | 5.0 | 5.0 | ..... |
| 17 | | 9.3 | 7.1 | 5.3 | 5.0 | 5.0 | 5.0 | ..... |
| 18 | | 9.1 | 7.1 | 5.3 | 5.0 | 5.0 | 5.0 | ..... |
| 19 | | 9.8 | 6.8 | 5.3 | 5.0 | 5.0 | 5.0 | ..... |
| 20 | | 9.7 | 6.8 | 5.3 | 5.0 | 5.0 | 5.0 | ..... |
| 21 | | 9.9 | 6.7 | 5.4 | 5.0 | 5.0 | 5.0 | ..... |
| 22 | | 9.9 | 6.7 | 5.3 | 5.0 | 5.0 | 5.0 | ..... |
| 23 | 7.5 | 9.8 | 6.6 | 5.2 | 5.0 | 5.0 | 5.0 | ..... |
| 24 | 7.05 | 9.7 | 6.6 | 5.2 | 5.0 | 5.0 | 5.0 | ..... |
| 25 | 7.0 | 9.8 | 6.7 | 5.1 | 5.0 | 5.0 | 5.0 | ..... |
| 26 | 7.0 | 7.7 | 6.9 | 5.1 | 5.0 | 5.0 | 5.0 | ..... |
| 27 | 6.5 | 7.4 | 6.4 | 5.1 | 5.0 | 5.0 | 5.0 | ..... |
| 28 | 6.4 | 7.1 | 6.2 | 5.1 | 5.0 | 5.0 | 5.0 | ..... |
| 29 | [a]9.0 | 7.4 | 5.9 | 5.1 | 5.0 | 5.0 | 5.0 | ..... |
| 30 | 6.0 | 7.7 | 5.7 | 5.1 | 5.0 | 4.9 | 5.0 | ..... |
| 31 | 6.1 | ..... | 6.0 | 5.1 | ..... | 4.9 | ..... | ..... |

[a] Backwater from snow.

NOTE.—There was practically no flow after September 1.

## TENAYA CREEK IN YOSEMITE VALLEY, CALIFORNIA.

This station was established July 11, 1904. It is located by the wagon bridge, about 2 miles from Yosemite, Cal. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 207, where are given also references to publications that contain data for previous years.

The following measurement was made June 11, 1906.:

Width, 44 feet; area, 176 square feet; gage height, 720 feet; discharge, 891 second-feet.

*Daily gage height, in feet, of Tenaya Creek in Yosemite Valley, Cal., for 1906.*

| Day. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| 1 | | 5.6 | 7.1 | 4.6 | 3.5 | 3.0 | 3.0 | 3.0 |
| 2 | | 5.7 | 7.2 | 4.4 | 3.4 | 3.0 | 3.0 | 3.0 |
| 3 | | 6.0 | 7.3 | 4.5 | 3.4 | 3.0 | 3.0 | 3.0 |
| 4 | | 6.0 | 7.2 | 4.4 | 3.3 | 3.0 | 3.2 | 3.0 |
| 5 | | 6.3 | 7.2 | 4.3 | 3.2 | 2.9 | 3.2 | 3.0 |
| 6 | | 6.0 | 7.1 | 4.4 | 3.2 | 2.9 | 3.1 | 3.0 |
| 7 | | 6.1 | 7.2 | 4.4 | 3.1 | 2.9 | 3.1 | 3.0 |
| 8 | | 6.3 | 7.1 | 4.3 | 3.0 | 2.9 | 3.0 | 3.0 |
| 9 | | 6.7 | 7.0 | 4.3 | 3.0 | 2.9 | 3.0 | 3.0 |
| 10 | | 6.8 | 6.7 | 4.4 | 3.0 | 2.9 | 3.0 | 3.0 |
| 11 | | 6.9 | 6.6 | 4.3 | 3.0 | 2.9 | 3.0 | 3.0 |
| 12 | | 6.9 | 7.0 | 4.2 | 2.9 | 2.9 | 3.0 | ..... |
| 13 | | 7.0 | 7.1 | 4.2 | 3.0 | 2.9 | 3.0 | ..... |
| 14 | | 7.1 | 7.0 | 4.1 | 3.0 | 3.0 | 3.0 | ..... |
| 15 | | 7.4 | 6.5 | 4.1 | 3.1 | 3.0 | 3.0 | ..... |

*Daily gage height, in feet, of Tenaya Creek in Yosemite Valley, Cal., for 1906*—Cont'd.

| Day. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| 16 | ..... | 8.1 | 6.3 | 4.0 | 3.0 | 2.9 | 3.0 | ..... |
| 17 | ..... | 7.8 | 6.2 | 4.0 | 3.0 | 2.9 | 3.0 | ..... |
| 18 | ..... | 7.3 | 6.1 | 3.9 | 3.0 | 3.0 | 3.0 | ..... |
| 19 | ..... | 7.1 | 6.0 | 3.8 | 3.0 | 2.9 | 3.0 | ..... |
| 20 | ..... | 7.5 | 5.8 | 3.9 | 3.0 | 2.9 | 3.0 | ..... |
| 21 | ..... | 7.4 | 5.6 | 3.8 | 3.0 | 2.9 | 3.0 | ..... |
| 22 | ..... | 7.3 | 5.5 | 3.8 | 3.0 | 2.9 | 3.0 | ..... |
| 23 | ..... | 7.4 | 5.5 | 3.8 | 3.0 | 3.0 | 3.0 | ..... |
| 24 | ..... | 7.4 | 5.4 | 3.7 | 3.0 | 2.9 | 3.0 | ..... |
| 25 | 6.2 | 7.5 | 5.5 | 3.6 | 3.0 | 2.9 | 3.0 | ..... |
| 26 | 6.1 | 6.1 | 5.7 | 3.6 | 3.0 | 2.9 | 3.0 | ..... |
| 27 | 5.9 | 6.0 | 5.7 | 3.5 | 3.0 | 3.0 | 3.0 | ..... |
| 28 | 5.7 | 6.4 | 5.2 | 3.5 | 3.0 | 2.9 | 3.0 | ..... |
| 29 | 5.5 | 6.6 | 5.0 | 3.4 | 3.0 | 2.9 | 3.0 | ..... |
| 30 | 5.5 | 6.9 | 4.7 | 3.4 | 3.0 | 3.0 | 3.0 | ..... |
| 31 | 5.5 | ..... | 4.7 | 3.4 | ..... | 3.0 | ..... | ..... |

## TUOLUMNE RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Tuolumne River rises on the western slope of the Sierra Nevada and drains the country located between Stanislaus River on the north and Merced River on the south. It has numerous tributaries, several of which produce a heavy discharge. The country throughout this basin is rough and rugged, especially along the main river, which cuts through solid granite, with high precipitous cliffs on either side. Along this stream is found some of the grandest scenery of the Sierra Nevada. This stream drains the northern portion of the Yosemite National Park, where is located the Grand Canyon of the Tuolumne and the Hetch Hetchy Valley, declared by many to exceed the famed Yosemite Valley in grandeur and beauty. The formation is of granite, which on the higher elevations is bare and glaciated, often rising thousands of feet in vertical cliffs and domes. Along the middle reaches of this basin there is good soil covering, with a heavy timber growth of pine, fir, cedar, and other kindred trees. On the lower reaches the covering is a heavy growth of brush, which diminishes in the foothills where the stream enters the San Joaquin Valley. This portion of the basin has a light soil covering, with grass growth, which is used for pasturage. There are several glacial lakes throughout the upper reaches of this basin, many of the larger of which offer exceptional opportunities for the construction of storage reservoirs. There are also many reservoir sites on the main river. The stream has a a heavy fall, and the opportunities for power development are numerous. Several diversions are made above the gaging station, which is located at Lagrange, where the stream breaks from the foothills. The precipitation on the upper half of this basin falls in the form of snow, a greater portion of which disappears in the spring months, but on the higher elevations much remains until late in the summer. The mean annual rainfall varies from about 30 inches on the lower foothills to about 60 inches on the higher elevations.

## TUOLUMNE RIVER AT LA GRANGE, CAL.

This station was established August 29, 1895. It is located at the wagon bridge, in the town of La Grange. It is below the high dam, where the diversions are made by the Turlock and Modesto canals, and also below the head of the canal of the La Grange Ditch and Hydraulic Mining Company, which diverts water from the left bank of the river above the dam. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 209, where are given also references to publications that contain data for previous years.

*Discharge measurements of Tuolumne River at La Grange, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 18 | C. H. Lee | 314 | 1,360 | 5.80 | 1,870 |
| March 29 | R. S. Hawley | 342 | 2,060 | 7.71 | 6,220 |
| April 25 | do | 337 | 2,000 | 7.52 | 5,710 |
| May 15 | C. H. Lee | 348 | 2,550 | 8.80 | 11,000 |
| May 25 | W. C. Sawyer | 330 | 2,140 | 8.18 | 7,760 |
| May 28 | do | 370 | 2,970 | 10.45 | 15,900 |
| June 4 | do | 348 | 2,500 | 9.11 | 11,100 |
| June 14 | do | 380 | 2,810 | 10.10 | 14,800 |
| June 21 | do | 384 | 3,050 | 10.54 | 17,000 |
| June 29 | do | 342 | 2,360 | 8.62 | 9,750 |
| July 3 | do | 376 | 3,060 | 10.79 | 18,300 |
| July 11 | do | 366 | 2,610 | 9.00 | 11,800 |
| July 21 | do | 340 | 2,230 | 8.22 | 8,570 |
| July 31 | do | 331 | 1,790 | 6.80 | 4,150 |
| August 3 | do | 326 | 1,580 | 6.20 | 2,700 |
| August 6 | do | 320 | 1,440 | 5.78 | 1,890 |
| August 20 | W. F. Martin | 318 | 1,360 | 5.43 | 1,380 |
| November 21 | do | 298 | 983 | 4.26 | 197 |

*Daily gage height, in feet, of Tuolumne River at La Grange, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.2 | 4.85 | 6.0 | 8.15 | 7.1 | 8.3 | 9.8 | 6.4 | 3.45 | 3.45 | 4.1 | 4.2 |
| 2 | 4.1 | 4.9 | 5.9 | 8.1 | 7.3 | 8.25 | 10.4 | 6.25 | 3.45 | 3.45 | 4.1 | 4.2 |
| 3 | 4.0 | 4.8 | 6.1 | 7.85 | 7.5 | 8.55 | 10.65 | 6.3 | 3.45 | 3.45 | 4.1 | 4.2 |
| 4 | 4.0 | 4.8 | 6.3 | 7.3 | 7.75 | 9.1 | 10.6 | 6.1 | 3.45 | 3.45 | 4.1 | 4.3 |
| 5 | 4.0 | 4.8 | 6.2 | 7.05 | 8.4 | 9.35 | 10.3 | 5.95 | 3.45 | 3.45 | 4.8 | 4.35 |
| 6 | 3.7 | 4.8 | 6.2 | 7.05 | 9.7 | 8.55 | 10.25 | 5.9 | 3.45 | 3.45 | 4.6 | 4.4 |
| 7 | 3.75 | 4.75 | 6.1 | 7.05 | 9.45 | 8.1 | 10.05 | 5.9 | 3.45 | 3.45 | 4.55 | 4.4 |
| 8 | 3.7 | 4.8 | 6.1 | 7.1 | 9.25 | 8.25 | 10.1 | 5.9 | 3.45 | 3.45 | 4.35 | 4.3 |
| 9 | 3.3 | 4.85 | 6.3 | 7.15 | 9.6 | 8.9 | 9.85 | 5.95 | 3.4 | 3.8 | 4.4 | 3.9 |
| 10 | 3.3 | 4.95 | 6.4 | 7.45 | 9.8 | 9.5 | 9.1 | 5.75 | 3.0 | 3.85 | 4.4 | 4.65 |
| 11 | 3.3 | 5.5 | 6.55 | 7.6 | 10.15 | 10.2 | 9.2 | 5.9 | 3.0 | 3.85 | 4.35 | 7.8 |
| 12 | 3.4 | 5.0 | 9.7 | 7.45 | 9.25 | 10.9 | 9.3 | 5.9 | 3.0 | 3.9 | 4.35 | 7.2 |
| 13 | 6.45 | 4.85 | 7.9 | 7.3 | 8.8 | 11.0 | 9.65 | 5.75 | 3.0 | 3.9 | 4.35 | 5.5 |
| 14 | 8.2 | 5.1 | 7.5 | 7.1 | 8.75 | 9.9 | 9.5 | 5.7 | 3.0 | 3.9 | 4.6 | 5.05 |
| 15 | 6.75 | 6.35 | 11.4 | 7.35 | 8.8 | 9.6 | 9.1 | 5.5 | 3.0 | 3.9 | 4.8 | 4.9 |
| 16 | 6.6 | 6.0 | 9.1 | 7.45 | 8.4 | 10.65 | 8.8 | 5.4 | 3.0 | 4.0 | 4.3 | 4.8 |
| 17 | 6.9 | 5.55 | 6.75 | 7.55 | 8.3 | 10.8 | 8.7 | 5.35 | 3.0 | 3.9 | 4.35 | 4.8 |
| 18 | 10.55 | 5.6 | 6.65 | 7.6 | 8.75 | 9.6 | 8.35 | 5.3 | 3.0 | 3.9 | 4.35 | 4.75 |
| 19 | 11.65 | 5.7 | 6.65 | 7.75 | 9.4 | 10.2 | 8.3 | 5.3 | 3.0 | 3.9 | 4.35 | 4.75 |
| 20 | 7.3 | 6.45 | 6.85 | 7.8 | 9.45 | 10.45 | 8.1 | 5.4 | 3.0 | 3.9 | 4.35 | 4.75 |
| 21 | 6.7 | 7.2 | 6.75 | 8.0 | 9.0 | 10.5 | 8.3 | 5.4 | 3.0 | 4.2 | 4.3 | 4.75 |
| 22 | 6.3 | 6.85 | 6.35 | 8.0 | 8.7 | 10.45 | 8.05 | 5.7 | 3.0 | 4.2 | 4.2 | 4.75 |
| 23 | 5.9 | 6.4 | 7.8 | 9.0 | 8.25 | 10.3 | 8.2 | 5.6 | 3.05 | 3.8 | 4.25 | 4.8 |
| 24 | 5.5 | 6.25 | 12.45 | 8.45 | 8.0 | 10.15 | 8.2 | 5.35 | 3.05 | 4.1 | 4.3 | 4.9 |
| 25 | 5.35 | 6.3 | 11.3 | 7.6 | 8.0 | 10.4 | 8.5 | 5.2 | 3.05 | 4.15 | 4.2 | 5.35 |
| 26 | 5.4 | 6.25 | 10.55 | 7.3 | 9.6 | 9.9 | 8.0 | 3.6 | 3.05 | 4.1 | 4.2 | 7.4 |
| 27 | 5.25 | 6.0 | 7.9 | 7.35 | 9.5 | 9.0 | 7.9 | 3.5 | 3.05 | 4.1 | 4.15 | 7.3 |
| 28 | 5.2 | 6.55 | 7.9 | 7.55 | 10.4 | 8.35 | 7.6 | 3.45 | 3.05 | 4.1 | 4.15 | 6.8 |
| 29 | 5.0 | ..... | 7.05 | 7.4 | 9.1 | 8.6 | 7.2 | 3.45 | 3.05 | 4.1 | 3.3 | 6.1 |
| 30 | 4.95 | ..... | 8.4 | 7.15 | 8.4 | 9.2 | 6.8 | 3.45 | 3.05 | 4.1 | 4.15 | 5.7 |
| 31 | 4.9 | ..... | 10.2 | ..... | 8.2 | ..... | 6.6 | 3.45 | ..... | 4.1 | ..... | 6.45 |

*Rating table for Tuolumne River at La Grange, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.00 | 0 | 4.00 | 115 | 5.00 | 780 | 6.00 | 2,260 | 8.00 | 7,390 |
| 3.10 | 1 | 4.10 | 145 | 5.10 | 900 | 6.20 | 2,650 | 8.20 | 8,030 |
| 3.20 | 5 | 4.20 | 180 | 5.20 | 1,030 | 6.40 | 3,080 | 8.40 | 8,700 |
| 3.30 | 10 | 4.30 | 220 | 5.30 | 1,160 | 6.60 | 3,530 | 8.60 | 9,390 |
| 3.40 | 20 | 4.40 | 270 | 5.40 | 1,300 | 6.80 | 4,000 | 8.80 | 10,090 |
| 3.50 | 30 | 4.50 | 330 | 5.50 | 1,440 | 7.00 | 4,500 | 9.00 | 10,810 |
| 3.60 | 40 | 4.60 | 400 | 5.60 | 1,590 | 7.20 | 5,020 | 10.00 | 14,610 |
| 3.70 | 55 | 4.70 | 480 | 5.70 | 1,750 | 7.40 | 5,570 | 11.00 | 18,610 |
| 3.80 | 70 | 4.80 | 570 | 5.80 | 1,910 | 7.60 | 6,140 | | |
| 3.90 | 90 | 4.90 | 670 | 5.90 | 2,080 | 7.80 | 6,750 | | |

NOTE.—This table is based on 18 discharge measurements made during 1906 and earlier low water measurements, and is well defined.

*Monthly discharge of Tuolumne River at La Grange, Cal., for 1906.*

[Drainage area, 1,500 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft per sq. mile. | Depth in inches. |
| January | 21,400 | 55 | 2,860 | 176,000 | 1.91 | 2.20 |
| February | 5,330 | 1,110 | 2,180 | 121,000 | 1.45 | 1.51 |
| March | 24,400 | 2,320 | 7,180 | 441,000 | 4.79 | 5.52 |
| April | 11,300 | 4,730 | 6,500 | 387,000 | 4.33 | 4.83 |
| May | 16,800 | 5,510 | 11,100 | 682,000 | 7.40 | 8.53 |
| June | 19,600 | 8,640 | 13,900 | 827,000 | 9.27 | 10.34 |
| July | 18,200 | 4,530 | 11,600 | 713,000 | 7.73 | 8.91 |
| August | 4,080 | 770 | 2,220 | 136,000 | 1.48 | 1.71 |
| September | 831 | 288 | 470 | 28,000 | .313 | .35 |
| October | 307 | 70 | 216 | 13,300 | .144 | .17 |
| November | 570 | 10 | 243 | 14,500 | .162 | .18 |
| December | 6,750 | 90 | 1,470 | 90,400 | .980 | 1.13 |
| The year | 24,400 | 10 | 4,990 | 3,630,000 | 3.33 | 45.38 |

NOTE.—These discharges include those of Modesto and Turlock canals. Values are excellent, except those for Modesto canal for April, September, and October, which are classed as good, on account of the lack of measurements of the canal at low stages.

## MODESTO CANAL AT LA GRANGE, CAL.

The Modesto canal is the property of the Modesto irrigation district. The water is diverted from the right side of Tuolumne River at the La Grange dam. This canal was designed to carry 660 second-feet and to irrigate land in the vicinity of Modesto, Stanislaus County, Cal. The principal part of the construction work was done on this canal prior to 1892, but on account of litigation the canal was not completed until April, 1903.

Information in regard to this station is contained in Water-Supply Papers Nos. 100, 134, and 177 of the United States Geological Survey.

During 1906 gagings were made about 500 feet below the intake at the La Grange dam. The canal at this point has a concrete section, the width being 20.2 feet at the bottom and the walls having a batter of about 1 to 5 outward. The floor of the canal is practically a plain surface, but the left side is 0.26 foot lower than the right side, where the highest velocity occurs. Measurements were made from the upper

side of a plank footbridge. The gage is an iron bar 1½ by ¼ inches, graduated into feet and tenths and placed in a concrete well on the left side of the canal about 400 feet above the gaging station. The well is connected to the canal by means of a small pipe from the bottom at right angles to the canal wall.

*Discharge measurements of Modesto canal at La Grange, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 16 | C. H. Lee | 22 | 59 | 2.80 | 395 |
| June 5 | W. C. Sawyer | 21 | 43 | 2.11 | 302 |
| June 5 | do | 21 | 39 | 1.91 | 257 |
| June 8 | do | 21 | 58 | 2.79 | 393 |
| June 8 | do | 21 | 56 | 2.70 | 412 |
| June 29 | do | 22 | 70 | 2.66 | 387 |
| July 2 | do | 21 | 69 | 2.60 | 380 |
| July 11 | do | 21 | 70 | 2.60 | 383 |
| July 19 | do | 21 | 68 | 2.52 | 376 |
| August 6 | Sawyer and Martin | 21 | 66 | 2.46 | 362 |
| September 5 | W. F. Martin | 21 | 46 | 1.70 | 250 |

*Daily gage height, in feet, of Modesto canal at La Grange, Cal., for 1906.*

| Day. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|
| 1 | | | 2.4 | 0.2 | 2.6 | 2.5 | 2.25 | 0.85 |
| 2 | | | 2.5 | .85 | 2.6 | 2.45 | 1.95 | .85 |
| 3 | | | 2.6 | 1.1 | 2.6 | 2.45 | 1.8 | .85 |
| 4 | | | 2.5 | 1.5 | 2.6 | 2.45 | 1.6 | .85 |
| 5 | | | 2.65 | 1.9 | 2.55 | 2.45 | 1.65 | .85 |
| 6 | | | 2.8 | 2.2 | 2.6 | 2.5 | 1.6 | .85 |
| 7 | | | 2.8 | 2.6 | 2.55 | 2.5 | 1.55 | .85 |
| 8 | | | 2.8 | 2.7 | 2.6 | 2.5 | 1.55 | .8 |
| 9 | | 1.4 | 2.8 | 2.85 | 2.55 | 2.45 | 1.5 | .9 |
| 10 | | 2.0 | 2.8 | 2.75 | 2.55 | 1.85 | 1.35 | .95 |
| 11 | | 2.0 | 2.8 | 2.5 | 2.6 | | 1.45 | .85 |
| 12 | | 1.95 | 2.8 | 2.5 | 2.6 | | 1.45 | .85 |
| 13 | 1.5 | 2.25 | 2.8 | 2.5 | 2.6 | | 1.4 | .9 |
| 14 | .65 | 2.3 | 2.8 | 1.65 | 2.6 | | 1.25 | 1.1 |
| 15 | 1.15 | 2.3 | 2.8 | 2.6 | 2.6 | | 1.35 | 1.05 |
| 16 | 1.5 | 2.35 | 2.8 | 2.55 | 2.6 | | 1.35 | 1.0 |
| 17 | 1.7 | 2.3 | 2.8 | 2.5 | 2.6 | | 1.3 | 1.0 |
| 18 | 1.8 | 2.3 | 2.8 | 2.5 | 2.5 | | 1.2 | .95 |
| 19 | 2.0 | 2.3 | 2.8 | 2.6 | 2.5 | | 1.15 | .95 |
| 20 | | 2.4 | 2.8 | 2.6 | 2.45 | | 1.05 | .95 |
| 21 | | 2.5 | 2.8 | 2.6 | 2.5 | | 1.05 | |
| 22 | | | 2.8 | 2.6 | 2.5 | | 1.0 | |
| 23 | | | 1.5 | 2.6 | 2.5 | 0.6 | .95 | |
| 24 | | | | 2.6 | 2.5 | .5 | .95 | |
| 25 | | | | 2.6 | 2.5 | 1.3 | .95 | |
| 26 | | | | 2.55 | 2.45 | 1.9 | 1.0 | |
| 27 | | | | 2.55 | 2.5 | 2.1 | 1.0 | |
| 28 | | | | 2.6 | 2.5 | 2.2 | .95 | |
| 29 | | 2.45 | | 2.6 | 2.5 | 1.95 | .9 | |
| 30 | | 2.5 | 2.65 | | 2.5 | 1.95 | .85 | |
| 31 | | | | | 2.5 | 1.9 | | |

NOTE.—No gage height record was kept April 22 to 28. Discharges have been interpolated. The canal was dry on other days on which the gage was not read.

*Rating table for Modesto canal at La Grange, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.50 | 90 | 1.10 | 156 | 1.70 | 238 | 2.30 | 328 | 2.90 | 428 |
| 0.60 | 100 | 1.20 | 169 | 1.80 | 253 | 2.40 | 344 | 3.00 | 445 |
| 0.70 | 110 | 1.30 | 182 | 1.90 | 268 | 2.50 | 360 | | |
| 0.80 | 120 | 1.40 | 196 | 2.00 | 283 | 2.60 | 377 | | |
| 0.90 | 131 | 1.50 | 210 | 2.10 | 298 | 2.70 | 394 | | |
| 1.00 | 143 | 1.60 | 224 | 2.20 | 313 | 2.80 | 411 | | |

NOTE.—This table is based on 11 discharge measurements made during 1906, and is well defined between gage heights 1.7 feet and 2.8 feet. Discharges have been included with those of Tuolumne River, page —. The total discharge of the canal for 1906 was 105,000 acre-feet.

## TURLOCK CANAL AT LA GRANGE, CAL.

The Turlock canal, the property of the Turlock irrigation district, takes water from the left bank of Tuolumne River at the La Grange dam. This canal was designed to carry 1,500 second-feet and to irrigate a large area of fertile land in the vicinity of Turlock and Ceres, Stanislaus County, Cal.

During 1898 water was first turned into the canal in small quantities and used for puddling the banks. A record of the gage height has been kept since July, 1899. The conditions at this station are described in Water-Supply Paper No. 177, page 214, where are given also references to publications that contain data for previous years.

*Discharge measurements of Turlock canal at La Grange, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 16 | C. H. Lee | 20 | 110 | 5.55 | 573 |
| May 24 | W. C. Sawyer | 20 | 113 | 5.75 | 601 |
| May 29 | do | 20 | 26 | 1.30 | 46 |
| May 29 | do | 20 | 40 | 2.05 | 109 |
| May 29 | do | 20 | 58 | 2.97 | 214 |
| May 29 | do | 20 | 58 | 2.97 | 218 |
| May 29 | do | 20 | 74 | 3.75 | 295 |
| May 29 | do | 20 | 92 | 4.70 | 430 |
| May 30 | do | 20 | 105 | 5.35 | 523 |
| May 30 | do | 20 | 118 | 6.02 | 627 |
| June 7 | do | 20 | 108 | 5.50 | 551 |
| July 2 | do | 20 | 115 | 6.02 | 624 |
| July 19 | do | 20 | 98 | 5.02 | 469 |
| July 21 | do | 20 | 21 | 1.08 | 30 |
| August 6 | Sawyer and Martin | 20 | 120 | 6.10 | 660 |
| August 20 | W. F. Martin | 20 | 120 | 6.10 | 696 |
| September 5 | do | 20 | 87 | 4.46 | 423 |

*Daily gage height, in feet, of Turlock canal at La Grange, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 5.25 | 3.25 | ..... | 4.5 | 5.0 | 6.05 | 6.05 | 5.05 | 2.5 |
| 2 | ..... | 5.6 | 3.25 | 2.0 | 4.1 | 5.0 | 6.05 | 6.05 | 5.25 | 2.4 |
| 3 | ..... | 5.6 | 2.9 | 2.0 | 4.4 | 5.0 | 6.05 | 6.05 | 4.1 | 2.4 |
| 4 | ..... | 5.6 | 2.4 | 2.0 | 5.4 | 5.0 | 6.0 | 6.05 | 4.35 | 2.4 |
| 5 | ..... | 5.7 | 2.0 | 2.0 | 5.35 | 5.6 | 6.05 | 6.05 | 4.4 | 2.4 |
| 6 | ..... | 5.7 | 2.0 | 2.0 | 5.35 | 5.5 | 6.05 | 6.0 | 4.3 | 2.4 |
| 7 | ..... | 5.7 | 2.0 | 2.0 | 5.35 | 5.5 | 6.05 | 6.05 | 4.25 | 2.35 |
| 8 | 2.05 | 5.7 | 2.0 | 2.0 | 5.35 | 5.65 | 6.05 | 6.05 | 4.2 | 2.3 |
| 9 | 2.05 | 5.75 | ..... | 2.0 | 5.35 | 5.75 | 6.05 | 6.05 | 4.05 | ..... |
| 10 | 2.65 | 4.65 | ..... | ..... | 5.6 | 5.75 | 6.05 | 6.05 | 3.75 | ..... |

*Daily gage height, in feet, of Turlock canal at La Grange, Cal., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 2.65 | 5.7 | ..... | ..... | 5.6 | 5.8 | 6.05 | 6.05 | 3.9 | ..... |
| 12 | 2.7 | 5.9 | ..... | 2.5 | 5.6 | 5.8 | 6.05 | 6.05 | 3.9 | ..... |
| 13 | 2.7 | 5.1 | ..... | 2.6 | 5.6 | 5.8 | 6.05 | 6.05 | 3.8 | ..... |
| 14 | 2.6 | 4.55 | ..... | 2.5 | 5.6 | 5.8 | 6.05 | 6.05 | 3.4 | ..... |
| 15 | 2.5 | 5.1 | ..... | 2.5 | 5.6 | 5.5 | 6.05 | 6.05 | 3.5 | ..... |
| 16 | 2.55 | 5.4 | ..... | 2.5 | 5.6 | 6.0 | 6.05 | 6.05 | 3.4 | ..... |
| 17 | 2.6 | 2.25 | ..... | 2.5 | 5.6 | 6.0 | 6.05 | 6.05 | 3.4 | ..... |
| 18 | 2.1 | ..... | ..... | 2.5 | 5.6 | 6.0 | 6.05 | 6.05 | 3.0 | ..... |
| 19 | 2.5 | 3.0 | ..... | 2.5 | 5.6 | 6.0 | 5.08 | 6.0 | 3.05 | ..... |
| 20 | 2.7 | 3.7 | ..... | 2.5 | 5.6 | 6.0 | 6.05 | 6.05 | 2.85 | ..... |
| 21 | 2.7 | 3.75 | 0.75 | 2.6 | 5.7 | 6.0 | 6.05 | 6.05 | 2.85 | ..... |
| 22 | 2.7 | 4.6 | 2.0 | 2.6 | 5.8 | 6.0 | 6.05 | 0.0 | 2.75 | ..... |
| 23 | 2.8 | 4.0 | 1.25 | 2.6 | 5.8 | 6.0 | 6.05 | 0.0 | 2.75 | ..... |
| 24 | 2.4 | 3.2 | ..... | 2.6 | 5.85 | 6.0 | 6.05 | 5.02 | 2.7 | ..... |
| 25 | 0.5 | 3.5 | ..... | 2.6 | 5.05 | 6.05 | 6.05 | 5.02 | 2.7 | ..... |
| 26 | 1.7 | 3.5 | ..... | 3.15 | 5.9 | 6.0 | 6.05 | 5.45 | 2.75 | ..... |
| 27 | 3.7 | 3.5 | ..... | 3.6 | 4.7 | 6.05 | 6.05 | 5.87 | 2.75 | ..... |
| 28 | 3.9 | 3.5 | ..... | 3.6 | 5.7 | 6.05 | 6.05 | 5.04 | 2.7 | ..... |
| 29 | 3.9 | ..... | ..... | 3.6 | 5.45 | 6.05 | 6.05 | 5.05 | 2.6 | ..... |
| 30 | 5.1 | ..... | ..... | 4.0 | 5.6 | 6.05 | 6.05 | 5.15 | 2.55 | ..... |
| 31 | 5.1 | ..... | ..... | ..... | 5.3 | ..... | 6.05 | 5.00 | ..... | ..... |

NOTE.—The canal was dry on days when the gage was not read.

*Rating table for Turlock canal at La Grange, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.50 | 4 | 1.50 | 58 | 2.50 | 156 | 3.50 | 274 | 5.00 | 478 |
| 0.60 | 6 | 1.60 | 67 | 2.60 | 167 | 3.60 | 287 | 5.20 | 508 |
| 0.70 | 10 | 1.70 | 76 | 2.70 | 178 | 3.70 | 300 | 5.40 | 538 |
| 0.80 | 14 | 1.80 | 85 | 2.80 | 189 | 3.80 | 313 | 5.60 | 568 |
| 0.90 | 19 | 1.90 | 94 | 2.90 | 201 | 3.90 | 326 | 5.80 | 598 |
| 1.00 | 25 | 2.00 | 104 | 3.00 | 213 | 4.00 | 339 | 6.00 | 628 |
| 1.10 | 31 | 2.10 | 114 | 3.10 | 225 | 4.20 | 365 | | |
| 1.20 | 37 | 2.20 | 124 | 3.20 | 237 | 4.40 | 392 | | |
| 1.30 | 44 | 2.30 | 134 | 3.30 | 249 | 4.60 | 420 | | |
| 1.40 | 51 | 2.40 | 145 | 3.40 | 261 | 4.80 | 448 | | |

NOTE.—This table is based on 17 discharge measurements made during 1906 and is well defined above gage heights 1 foot. Discharges have been included with those for Tuolumne River, p —. The total discharge of the canal for 1906 was 202,000 acre-feet.

## STANISLAUS RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Stanislaus River drains a portion of the western slope of the Sierra Nevada and heads well back on the crest, at elevations of from 10,000 to 12,000 feet. It drains the country between the basins of Mokelumne River on the north and Tuolumne River on the south, and flows in a general southwesterly direction, entering San Joaquin River 23 miles above Stockton. In the upper reaches of the basin it has many tributaries, which have their source in numerous small glacial lakes. The topography is rough and broken, with high mountain peaks. The formation is of granite, which is bare and destitute of timber growth above an elevation of 8,000 feet, except where small glacial lakes and moraines occur. In the middle reaches of the basin there is good soil covering and a heavy growth of timber. In this basin is situated the Calaveras grove of big trees (*Sequoia gigantea*), for which the Sierra Nevada is famous. This is the most north-

erly of the groves of these trees which extend as far south as the Kern River basin. The mean annual rainfall for the basin is about 50 inches. The precipitation falls chiefly in the form of snow on the higher elevations, remaining well into the summer months. Mining operations have been carried on extensively in this basin, and many canals have been taken out of the river, all of which discharge into the river again. The canal of the Stanislaus Water Company diverts water 3 miles above Knights Ferry and is used to irrigate land between Knights Ferry and Stockton. A gaging station is maintained on this canal to determine its discharge.

### STANISLAUS RIVER AT KNIGHTS FERRY, CAL.

A station was first established on this river on May 3, 1895, at the railroad bridge one-half mile north of Oakdale. On July 30, 1898, a cable was placed 1,000 feet below the railroad bridge. This station was used until February 16, 1901.

The station at Knights Ferry was established May 19, 1903. It is located 200 feet from the post-office at Knights Ferry. The conditions at this station and the bench marks are described in Water Supply Paper No. 177, page 217, where are given also references to publications that contain data for previous years.

*Discharge measurements of Stanislaus River at Knights Ferry, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 19 | C. H. Lee | 194 | 793 | 9.20 | 2,740 |
| March 29 | R. S. Hawley | 221 | 989 | 10.37 | 3,920 |
| April 24 | do | 230 | 1,030 | 10.60 | 4,370 |
| April 25 | Hawley and Ostrom | 225 | 1,040 | 10.43 | 4,560 |
| April 30 | G. A. Ostrom | 213 | 980 | 10.00 | 4,310 |
| May 3 | do | 268 | 1,280 | 11.52 | 7,090 |
| May 5 | do | 297 | 1,630 | 12.52 | 9,690 |
| May 7 | do | 323 | 1,870 | 13.35 | 11,800 |
| May 10 | do | 329 | 1,900 | 13.56 | 12,900 |
| May 15 | do | 295 | 1,660 | 12.58 | 10,100 |
| May 15 | Ostrom and Lee | 295 | 1,670 | 12.60 | 10,100 |
| May 22 | G. A. Ostrom | 274 | 1,380 | 11.72 | 7,550 |
| May 26 | W. C. Sawyer | 297 | 1,560 | 12.30 | 9,650 |
| June 2 | G. A. Ostrom | 245 | 1,240 | 11.23 | 6,780 |
| June 5 | do | 304 | 1,780 | 12.84 | 10,900 |
| June 11 | do | 345 | 2,200 | 13.95 | 12,700 |
| June 12 | do | 347 | 2,420 | 14.55 | 15,100 |
| June 13 | do | 348 | 2,570 | 14.71 | 17,000 |
| June 15 | W. C. Sawyer | 328 | 1,640 | 12.55 | 10,200 |
| June 21 | G. A. Ostrom | 291 | 1,860 | 13.40 | 12,300 |
| June 23 | W. C. Sawyer | 287 | 1,490 | 12.08 | 8,770 |
| June 29 | G. A. Ostrom | 242 | 1,260 | 10.98 | 6,640 |
| July 10 | W. C. Sawyer | 241 | 1,180 | 10.78 | 5,800 |
| July 14 | G. A. Ostrom | 245 | 1,290 | 11.22 | 6,890 |
| July 17 | do | 212 | 1,020 | 10.00 | 4,760 |
| July 20 | do | 194 | 849 | 9.30 | 3,360 |
| July 25 | do | 198 | 890 | 9.68 | 3,750 |
| July 28 | do | 185 | 762 | 8.70 | 2,500 |
| July 30 | do | 169 | 594 | 8.04 | 1,690 |
| August 1 | do | 160 | 521 | 7.63 | 1,330 |
| August 9 | do | 153 | 463 | 7.16 | 1,020 |
| August 16 | do | 140 | 388 | 6.68 | 634 |
| August 27 | do | 131 | 327 | 6.34 | 405 |
| September 5 | W. F. Martin | 128 | 299 | 6.13 | 273 |
| September 9 | G. A. Ostrom | 128 | 294 | 6.08 | 239 |
| September 18 | do | 121 | 254 | 5.86 | 170 |
| September 28 | do | 118 | 238 | 5.75 | 115 |
| October 9 | do | 114 | 227 | 5.64 | 71 |
| October 19 | do | 113 | 221 | 5.58 | 71 |
| November 23 | W. F. Martin | 125 | 256 | 5.82 | 129 |

*Daily gage height, in feet, of Stanislaus River at Knights Ferry, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.4 | 7.15 | 8.6 | 11.5 | 10.25 | 10.8 | 12.0 | 7.8 | 6.3 | 5.8 | 5.7 | 5.8 |
| 2 | 6.3 | 7.2 | 8.4 | 10.8 | 10.8 | 11.1 | 12.2 | 7.75 | 6.25 | 5.8 | 5.7 | 5.8 |
| 3 | 6.3 | 7.25 | 8.45 | 10.3 | 11.4 | 11.4 | 12.4 | 7.65 | 6.25 | 5.8 | 5.7 | 5.7 |
| 4 | 6.3 | 7.3 | 9.3 | 9.95 | 11.8 | 12.3 | 12.3 | 7.55 | 6.15 | 5.8 | 5.85 | 5.8 |
| 5 | 6.25 | 7.25 | 8.8 | 9.75 | 12.35 | 12.5 | 12.15 | 7.45 | 6.15 | 5.8 | 6.45 | 5.8 |
| 6 | 6.3 | 7.35 | 8.65 | 9.7 | 12.95 | 11.4 | 11.75 | 7.4 | 6.1 | 5.8 | 6.15 | 5.8 |
| 7 | 6.3 | 7.35 | 8.6 | 9.7 | 12.7 | 11.05 | 11.6 | 7.4 | 6.1 | 5.85 | 5.9 | 5.8 |
| 8 | 6.25 | 7.3 | 8.55 | 9.8 | 12.85 | 11.3 | 11.6 | 7.35 | 6.1 | 5.75 | 5.9 | 6.2 |
| 9 | 6.3 | 7.35 | 8.65 | 11.0 | 12.85 | 12.05 | 11.2 | 7.3 | 6.1 | 5.75 | 5.85 | 5.9 |
| 10 | 6.3 | 7.4 | 8.7 | 10.4 | 12.9 | 12.85 | 10.6 | 7.25 | 6.15 | 5.75 | 5.85 | 6.05 |
| 11 | 6.3 | 7.5 | 8.8 | 10.3 | 13.35 | 13.5 | 10.5 | 7.2 | 6.15 | 5.8 | 5.85 | 13.1 |
| 12 | 7.9 | 7.35 | 11.1 | 9.9 | 12.15 | 14.1 | 10.65 | 7.1 | 6.1 | 5.75 | 5.85 | 9.95 |
| 13 | 11.35 | 7.35 | 10.5 | 10.0 | 11.65 | 13.85 | 11.1 | 7.0 | 6.0 | 5.75 | 5.9 | 7.65 |
| 14 | 10.45 | 7.5 | 10.15 | 10.2 | 11.8 | 12.8 | 10.8 | 7.0 | 6.0 | 5.75 | 5.7 | 6.85 |
| 15 | 9.1 | 8.8 | 13.2 | 10.3 | 12.3 | 12.8 | 10.4 | 6.8 | 6.0 | 5.75 | 5.6 | 6.55 |
| 16 | 8.8 | 8.3 | 10.6 | 10.6 | 11.3 | 13.4 | 10.0 | 6.75 | 6.0 | 5.9 | 5.6 | 6.55 |
| 17 | 9.9 | 8.0 | 9.9 | 10.55 | 11.2 | 13.15 | 9.95 | 6.7 | 6.0 | 5.7 | 5.6 | 6.3 |
| 18 | 13.25 | 7.95 | 9.35 | 10.75 | 11.8 | 12.4 | 9.55 | 6.65 | 5.95 | 5.7 | 5.7 | 6.2 |
| 19 | 14.1 | 8.95 | 9.05 | 10.8 | 12.1 | 13.0 | 9.3 | 6.7 | 5.9 | 5.7 | 5.65 | 6.2 |
| 20 | 9.9 | 8.7 | 9.0 | 11.15 | 12.1 | 12.9 | 9.3 | 6.8 | 5.85 | 5.7 | 5.6 | 6.15 |
| 21 | 8.9 | 9.9 | 9.2 | 11.4 | 11.9 | 12.9 | 9.25 | 6.7 | 5.8 | 5.7 | 5.7 | 6.1 |
| 22 | 8.4 | 9.85 | 9.75 | 11.6 | 11.5 | 12.8 | 9.3 | 6.6 | 5.8 | 5.75 | 5.7 | 6.1 |
| 23 | 8.05 | 9.3 | 10.2 | 11.85 | 11.0 | 12.45 | 9.5 | 6.55 | 5.8 | 5.7 | 5.7 | 6.25 |
| 24 | 7.9 | 9.25 | 14.1 | 10.9 | 10.9 | 12.15 | 9.45 | 6.45 | 5.8 | 5.75 | 5.75 | 6.35 |
| 25 | 7.75 | 9.4 | 14.3 | 10.4 | 10.8 | 12.55 | 9.4 | 6.35 | 5.85 | 5.75 | 5.8 | 7.65 |
| 26 | 7.65 | 8.95 | 13.0 | 10.2 | 11.9 | 12.1 | 9.2 | 6.3 | 5.9 | 5.75 | 5.8 | 9.3 |
| 27 | 7.55 | 8.8 | 11.5 | 10.3 | 11.7 | 11.1 | 9.0 | 6.25 | 5.9 | 5.75 | 5.8 | 9.35 |
| 28 | 7.5 | 9.0 | 10.75 | 10.5 | 12.05 | 10.7 | 8.7 | 6.25 | 5.8 | 5.7 | 5.8 | 8.45 |
| 29 | 7.5 | ..... | 10.4 | 10.1 | 11.1 | 10.8 | 8.4 | 6.2 | 5.8 | 5.7 | 5.8 | 7.75 |
| 30 | 7.45 | ..... | 11.1 | 10.0 | 10.75 | 11.2 | 8.15 | 6.2 | 5.75 | 5.7 | 5.8 | 7.45 |
| 31 | 7.3 | ..... | 13.55 | ..... | 10.6 | ..... | 7.95 | 6.3 | ..... | 5.7 | ..... | 8.3 |

*Rating table for Stanislaus River at Knights Ferry, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 5.60 | 65 | 6.70 | 640 | 7.80 | 1,540 | 8.90 | 2,800 | 11.00 | 6,140 |
| 5.70 | 95 | 6.80 | 710 | 7.90 | 1,640 | 9.00 | 2,930 | 11.20 | 6,540 |
| 5.80 | 130 | 6.90 | 790 | 8.00 | 1,740 | 9.20 | 3,200 | 11.40 | 6,970 |
| 5.90 | 170 | 7.00 | 870 | 8.10 | 1,850 | 9.40 | 3,480 | 11.60 | 7,410 |
| 6.00 | 220 | 7.10 | 950 | 8.20 | 1,960 | 9.60 | 3,760 | 11.80 | 7,880 |
| 6.10 | 270 | 7.20 | 1,030 | 8.30 | 2,070 | 9.80 | 4,060 | 12.00 | 8,390 |
| 6.20 | 320 | 7.30 | 1,110 | 8.40 | 2,190 | 10.00 | 4,380 | 13.00 | 11,110 |
| 6.30 | 380 | 7.40 | 1,190 | 8.50 | 2,310 | 10.20 | 4,710 | 14.00 | 14,020 |
| 6.40 | 440 | 7.50 | 1,270 | 8.60 | 2,430 | 10.40 | 5,050 | 15.00 | 17,180 |
| 6.50 | 500 | 7.60 | 1,360 | 8.70 | 2,550 | 10.60 | 5,400 | | |
| 6.60 | 570 | 7.70 | 1,450 | 8.80 | 2,670 | 10.80 | 5,760 | | |

NOTE.—This table is based on 40 discharge measurements made during 1906 and is well defined.

*Monthly discharge of Stanislaus River at Knights Ferry, Cal., for 1906.*

[Drainage area, 935 square miles.]

| Month. | Discharge in second-feet | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 14,400 | 386 | 2,470 | 152,000 | 2.64 | 3.04 |
| February | 4,290 | 1,060 | 2,070 | 115,000 | 2.21 | 2.30 |
| March | 14,900 | 2,200 | 5,330 | 328,000 | 5.70 | 6.57 |
| April | 8,110 | 3,920 | 5,330 | 317,000 | 5.70 | 6.36 |
| May | 12,200 | 4,920 | 8,090 | 497,000 | 8.65 | 9.97 |
| June | 14,400 | 5,590 | 9,340 | 556,000 | 9.99 | 11.15 |
| July | 9,600 | 1,790 | 5,210 | 320,000 | 5.57 | 6.42 |
| August | 1,600 | 415 | 910 | 56,000 | .973 | 1.12 |
| September | 490 | 207 | 309 | 18,400 | .330 | .37 |
| October | 251 | 162 | 193 | 11,900 | .206 | .24 |
| November | 551 | 87 | 181 | 10,800 | .194 | .22 |
| December | 11,400 | 141 | 1,270 | 78,100 | 1.36 | 1.57 |
| The year | 14,900 | 87 | 3,390 | 2,460,000 | 3.63 | 49.33 |

NOTE.—The discharge of Stanislaus Water Company's canal and Schell ditch is included above. The discharge of Schell ditch has been assumed as 7 second-feet. Values are excellent, except January to April, which are rated as fair, because measurements made during that period give a discharge somewhat less than the rating.

## STANISLAUS WATER COMPANY'S CANAL AT KNIGHTS FERRY, CAL.

This station was established June 11, 1904. It is located below the point where Schell ditch diverts its water, about 1 mile below the Stanislaus Milling and Power Company's power house and 200 feet below the place where it passes under the Schell-ditch flume. The water diverted by this ditch is used for irrigation in the vicinity of Oakdale, Cal.

*Discharge measurements of Stanislaus Water Company's canal at Knights Ferry, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| May 15 | C. H. Lee | 9 | 25.0 | 3.35 | 103 |
| May 26 | W. C. Sawyer | 9 | 26.3 | 3.48 | 108 |
| June 15 | do | 9 | 26.6 | 3.60 | 119 |
| July 10 | do | 9 | 29.0 | 3.77 | 132 |

*Daily gage height, in feet, of Stanislaus Water Company's canal at Knights Ferry, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.3 | 2.9 | ..... | 1.65 | 3.5 | 3.6 | 3.75 | 2.55 | 3.4 | 3.1 | 2.95 | 2.25 |
| 2 | 1.9 | 2.65 | ..... | 1.5 | 3.5 | 3.7 | 3.8 | 3.3 | 3.15 | 3.0 | 2.95 | 2.35 |
| 3 | 2.15 | 2.7 | ..... | 2.0 | 3.5 | 3.8 | 3.7 | 3.25 | 3.25 | 3.1 | 2.95 | 2.4 |
| 4 | 2.25 | 2.75 | ..... | 2.45 | 3.3 | 3.7 | 3.85 | 2.8 | 3.2 | 3.05 | 3.0 | 2.0 |
| 5 | 2.25 | 2.75 | ..... | 2.15 | 3.4 | 3.7 | 3.8 | 2.95 | 3.2 | 3.0 | 3.0 | 1.5 |
| 6 | 2.4 | 2.8 | ..... | ..... | 3.4 | 3.85 | 3.75 | 3.4 | 3.1 | 2.95 | 2.9 | 1.65 |
| 7 | 2.4 | 2.75 | ..... | ..... | 3.2 | 3.6 | 3.8 | 3.45 | 3.2 | 3.0 | 2.85 | 1.85 |
| 8 | 2.15 | 2.8 | 3.1 | ..... | 3.5 | 3.8 | 3.8 | 3.45 | 3.1 | 2.9 | 2.7 | 2.1 |
| 9 | 2.3 | 3.1 | 3.35 | 3.1 | 3.7 | 3.8 | 3.8 | 3.4 | 3.2 | 3.0 | 2.9 | 2.2 |
| 10 | 2.25 | 3.05 | 3.55 | 2.1 | 3.6 | 3.9 | 3.5 | 3.4 | 3.05 | 3.0 | 2.95 | 2.5 |
| 11 | 2.2 | 3.0 | 3.2 | 2.05 | 3.3 | 3.8 | 3.8 | 3.4 | 3.0 | 3.05 | 2.95 | 1.9 |
| 12 | 2.35 | 2.5 | 3.0 | 2.65 | 3.5 | 3.6 | 2.7 | 3.3 | 2.95 | 3.0 | 2.5 | 2.05 |
| 13 | 2.45 | 2.2 | 2.85 | 2.7 | 3.6 | 3.65 | 3.75 | 3.2 | 2.95 | 3.0 | 2.5 | 2.0 |
| 14 | 2.65 | 2.6 | 2.7 | 2.8 | 3.5 | 3.7 | 3.8 | 3.1 | 2.9 | 3.15 | 2.22 | 1.75 |
| 15 | 2.6 | 3.0 | 2.45 | 3 0 | 3.55 | 3.7 | 3.2 | 3.15 | 3.1 | 3.05 | 1.9 | 1.6 |
| 16 | 2.6 | 3.05 | 2.45 | 3.3 | 3.35 | 3.75 | 2.85 | 3.3 | 3.1 | 3.0 | 2.12 | 1.3 |
| 17 | 2.75 | 3.1 | 2.2 | 3.4 | 3.6 | 3.55 | 3.2 | 3.3 | 2.85 | 3.05 | 2.05 | 1.9 |
| 18 | 2.1 | 3.15 | 2.2 | 3.5 | 3.3 | 3.6 | 2.95 | 3.1 | 3.1 | 2.9 | 1.4 | 1.65 |
| 19 | 2.5 | 2.75 | 2.6 | 3.55 | 3.6 | 3.6 | 3.5 | 3.2 | 3.1 | 2.95 | 1.45 | 1.4 |
| 20 | 2.2 | 2.8 | 3.0 | 3.6 | 3.65 | 3.6 | 3.0 | 3.5 | 3.15 | 2.8 | 1.7 | 1.8 |
| 21 | 2.15 | 2.9 | 2.8 | 3.55 | 3.65 | 3.6 | 3.55 | 3.5 | 3.2 | 2.8 | 1.1 | 2.35 |
| 22 | 1.5 | 2.8 | 3.0 | 3.65 | 3.75 | 3.55 | 2.8 | 3.4 | 3.2 | 2.85 | 1.15 | 2.4 |
| 23 | 1.35 | 2.75 | 3.0 | 3.35 | 3.75 | 3.6 | 3.6 | 3.4 | 3.15 | 2.9 | 1.15 | 2.45 |
| 24 | ..... | 2.8 | 2.1 | ..... | 3.75 | 3.25 | 3.7 | 3.4 | 3.1 | 2.9 | 1.65 | 2.3 |
| 25 | ..... | 2.45 | ..... | 3.6 | 3.7 | 3.6 | 3.7 | 3.15 | 3.05 | 2.9 | 1.65 | 1.95 |
| 26 | ..... | ..... | ..... | 3.7 | 3.6 | 3.7 | 3.7 | 3.4 | 3.0 | 2.95 | 2.25 | 1.9 |
| 27 | ..... | ..... | ..... | 3.6 | 3.6 | ..... | 3.7 | 3.3 | 3.15 | 2.9 | 2.3 | 2.25 |
| 28 | ..... | ..... | ..... | 3.5 | 3.1 | ..... | 3.2 | 3.25 | 3.2 | 2.9 | 2.3 | 2.1 |
| 29 | ..... | ..... | ..... | 3.3 | 3.3 | 3.0 | 3.65 | 3.2 | 3.05 | 2.85 | 2.35 | 2.1 |
| 30 | ..... | ..... | ..... | 3.3 | 3.5 | 3.25 | 3.45 | 3.2 | 3.2 | 2.95 | 2.15 | 2.3 |
| 31 | 2.65 | ..... | ..... | ..... | 3.5 | ..... | 3.3 | 3.4 | ..... | 3.0 | ..... | 2.3 |

NOTE.—Canal was dry on days when gage was not read.

*Rating table for Stanislaus Water Company's canal at Knights Ferry for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.70 | 0 | 1.40 | 9 | 2.10 | 27 | 2.80 | 60 | 3.50 | 111 |
| 0.80 | 0.7 | 1.50 | 11 | 2.20 | 31 | 2.90 | 67 | 3.60 | 119 |
| 0.90 | 1.5 | 1.60 | 13 | 2.30 | 35 | 3.00 | 74 | 3.70 | 127 |
| 1.00 | 2.5 | 1.70 | 15 | 2.40 | 39 | 3.10 | 81 | 3.80 | 135 |
| 1.10 | 4.0 | 1.80 | 17 | 2.50 | 44 | 3.20 | 88 | 3.90 | 143 |
| 1.20 | 5.5 | 1.90 | 20 | 2.60 | 49 | 3.30 | 95 | 4.00 | 151 |
| 1.30 | 7 | 2.00 | 23 | 2.70 | 54 | 3.40 | 103 | | |

NOTE.—This table is based on 13 discharge measurements made during 1905–6 and is well defined. Discharges have been included in those for Stanislaus River, p. 170. The total discharge of the canal in 1906 was 50,300 acre-feet.

## MOKELUMNE RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Mokelumne River drains an area of 657 square miles of the western slope of the Sierra Nevada. It has numerous tributaries, North, South, and Middle forks being the most important. This stream heads well back in the main crest of the Sierra Nevada at an elevation of 8,000 feet.

The formation is of granite, with good soil covering and heavy timber growth on the middle and higher elevations. On the lower elevations the slopes are less rugged and the soil covering is of brush and scattering oak timber, with large areas of cultivated land and pasture. There are numerous small glacial lakes and moraines in the upper reaches of this basin. The precipitation varies from 25 inches on the lower to 50 inches on the higher elevations, where it falls in the form of snow, which melts in the early spring. The greatest discharge usually occurs in April, May, and June. There is some artificial storage in this basin, but not enough to have much effect on the discharge.

Several diversions are made for mining and power purposes within the drainage basin, and this water is returned to the river above the gaging station, which is located at Clements, a few miles above Lodi, Cal.

### MOKELUMNE RIVER NEAR CLEMENTS, CAL.

This station was established October 28, 1904. It is located at the highway bridge, 1 mile north of Clements. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 223, where are given also references to publications that contain data for previous years.

*Discharge measurements of Mokelumne River near Clements, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 11 | F. R. S. Buttemer | 122 | 212 | 4.60 | 492 |
| February 27 | do | 248 | 584 | 6.50 | 1,460 |
| March 12 | do | 251 | 1,310 | 9.15 | 3,790 |
| March 19 | do | 247 | 616 | 6.48 | 1,500 |
| April 14 | W. C. Sawyer | 255 | 962 | 8.28 | 2,630 |
| April 20 | do | 248 | 1,260 | 9.40 | 3,780 |
| April 21 | do | 250 | 1,400 | 10.00 | 4,340 |
| April 28 | do | 248 | 1,000 | 8.40 | 2,750 |
| May 9 | do | 251 | 1,710 | 11.55 | 5,730 |
| May 10 | do | 249 | 1,870 | 12.18 | 6,450 |
| May 22 | do | 252 | 1,220 | 10.02 | 3,720 |
| May 23 | do | 248 | 1,090 | 9.50 | 3,170 |
| June 12 | do | 263 | 2,470 | 14.35 | 8,610 |
| June 13 | do | 263 | 2,460 | 14.29 | 8,730 |
| June 19 | do | 251 | 1,970 | 12.20 | 6,440 |
| June 20 | do | 256 | 2,330 | 13.68 | 7,680 |
| June 27 | do | 249 | 1,390 | 9.80 | 3,780 |
| June 28 | do | 249 | 1,320 | 9.60 | 3,480 |
| July 7 | do | 250 | 1,610 | 10.75 | 4,740 |
| July 17 | do | 248 | 1,080 | 8.69 | 2,760 |
| July 18 | do | 258 | 1,060 | 8.46 | 2,720 |
| July 28 | do | 236 | 602 | 6.52 | 1,340 |
| July 30 | do | 204 | 392 | 5.65 | 826 |
| August 7 | Sawyer and Martin | 131 | 188 | 4.52 | 400 |
| September 3 | W. F. Martin | 77 | 141 | 4.05 | 221 |
| November 24 | do | 57 | 113 | 3.77 | 163 |
| November 27 | R. S. Hawley | 55 | 107 | 3.75 | 161 |

*Daily gage height, in feet, of Mokelumne River near Clements, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.05 | 4.5 | 6.05 | 11.2 | 8.45 | 9.45 | 10.95 | 5.15 | 3.8 | 3.8 | 4.0 | 3.9 |
| 2 | 3.1 | 4.4 | 5.6 | 9.95 | 9.05 | 9.9 | 12.25 | 5.0 | 3.9 | 3.9 | 3.95 | 4.1 |
| 3 | 3.1 | 4.45 | 5.85 | 8.75 | 10.5 | 10.45 | 12.15 | 5.2 | 3.8 | 3.85 | 3.95 | 3.75 |
| 4 | 3.15 | 4.4 | 6.45 | 8.3 | 10.85 | 12.2 | 13.2 | 5.1 | 3.75 | 3.75 | 4.1 | 3.95 |
| 5 | 3.15 | 4.45 | 5.75 | 7.95 | 11.6 | 12.15 | 12.4 | 4.95 | 3.75 | 3.95 | 5.15 | 4.0 |
| 6 | 3.15 | 4.5 | 5.7 | 7.9 | 12.45 | 10.45 | 12.2 | 4.7 | 3.85 | 4.0 | 4.5 | 4.0 |
| 7 | 3.15 | 4.5 | 5.75 | 7.75 | 12.5 | 9.6 | 11.35 | 5.15 | 4.0 | 3.85 | 4.4 | 3.95 |
| 8 | 3.1 | 4.45 | 5.75 | 7.6 | 12.1 | 10.05 | 11.45 | 4.6 | 3.9 | 3.7 | 4.15 | 4.0 |
| 9 | 3.1 | 4.5 | 5.95 | 7.75 | 12.4 | 11.6 | 11.15 | 4.8 | 4.05 | 4.0 | 4.1 | 4.2 |
| 10 | 3.1 | 4.65 | 6.05 | 8.3 | 12.1 | 13.8 | 10.7 | 4.6 | 4.2 | 3.95 | 4.1 | 3.95 |
| 11 | 3.15 | 4.7 | 6.05 | 8.5 | 12.2 | 14.3 | 10.4 | 4.9 | 4.4 | 3.85 | 3.75 | 10.8 |
| 12 | 3.3 | 4.55 | 8.4 | 8.0 | 11.15 | 14.4 | 10.05 | 5.0 | ..... | 3.95 | 3.8 | 8.35 |
| 13 | 5.6 | 4.5 | 8.1 | 7.8 | 10.2 | 13.8 | 10.05 | 4.55 | 3.9 | 3.9 | 3.8 | 5.75 |
| 14 | 7.95 | 4.6 | 7.5 | 7.9 | 10.4 | 12.2 | 10.1 | 4.4 | 3.95 | 3.85 | 3.9 | 4.95 |
| 15 | 6.05 | 5.05 | 11.5 | 8.3 | 10.9 | 11.7 | 9.65 | 4.4 | 4.0 | 3.9 | 4.1 | 4.7 |
| 16 | 6.6 | 5.75 | 8.15 | 8.6 | 9.55 | 13.3 | 9.4 | 4.15 | 3.95 | 3.95 | 4.2 | 4.7 |
| 17 | 7.75 | 5.15 | 7.4 | 8.6 | 9.15 | 12.9 | 8.9 | 3.9 | 4.05 | 3.95 | 4.0 | 4.4 |
| 18 | 11.45 | 5.45 | 6.8 | 8.75 | 10.15 | 11.95 | 8.2 | 3.9 | 3.85 | 3.95 | 4.2 | 4.35 |
| 19 | 12.7 | 6.75 | 6.45 | 8.95 | 10.75 | 12.55 | 7.55 | 3.9 | 3.85 | 3.9 | 4.2 | 4.25 |
| 20 | 7.9 | 6.2 | 6.25 | 9.45 | 10.9 | 12.6 | 7.9 | 3.95 | 3.9 | 3.9 | 4.2 | 4.3 |
| 21 | 7.0 | 7.45 | 6.65 | 9.9 | 10.45 | 12.45 | 7.85 | 3.85 | 3.9 | 3.75 | 4.2 | 4.3 |
| 22 | 5.7 | 7.3 | 7.2 | 10.3 | 10.35 | 12.7 | 7.0 | 3.85 | 3.9 | 3.75 | 4.2 | 4.3 |
| 23 | 5.3 | 6.5 | 8.1 | 10.3 | 9.4 | 12.2 | 7.5 | 3.95 | 3.9 | 3.95 | 4.2 | 4.9 |
| 24 | 5.15 | 6.2 | 11.55 | 9.15 | 9.15 | 11.75 | 7.0 | 3.95 | 3.85 | 3.9 | 3.85 | 4.1 |
| 25 | 4.9 | 6.1 | 12.05 | 8.55 | 9.15 | 12.25 | 6.65 | 4.2 | 3.95 | 3.95 | 3.85 | 6.7 |
| 26 | 4.85 | 6.0 | 11.85 | 8.1 | 10.5 | 11.55 | 6.45 | 4.0 | 3.9 | 4.0 | 3.6 | 8.55 |
| 27 | 4.7 | 6.25 | 10.45 | 8.25 | 10.5 | 10.9 | 6.25 | 3.8 | 4.0 | 3.85 | 3.95 | 8.5 |
| 28 | 4.6 | 6.45 | 9.15 | 8.5 | 10.75 | 10.1 | 6.25 | 3.85 | 4.0 | 4.05 | 3.95 | 7.1 |
| 29 | 4.55 | ..... | 8.5 | 8.05 | 10.2 | 10.45 | 5.65 | 3.8 | 3.9 | 3.8 | 4.1 | 6.3 |
| 30 | 4.5 | ..... | 8.7 | 8.0 | 9.35 | 10.5 | 5.45 | 3.95 | 3.85 | 3.95 | 3.9 | 4.8 |
| 31 | 4.45 | ..... | 13.45 | ..... | 9.25 | ..... | 5.3 | 3.85 | ..... | 4.05 | ..... | 6.8 |

*Rating table for Mokelumne River near Clements, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.00 | 50 | 4.10 | 250 | 5.20 | 680 | 6.60 | 1,450 | 8.80 | 3,010 |
| 3.10 | 60 | 4.20 | 280 | 5.30 | 730 | 6.80 | 1,570 | 9.00 | 3,180 |
| 3.20 | 70 | 4.30 | 315 | 5.40 | 780 | 7.00 | 1,690 | 10.00 | 4,125 |
| 3.30 | 80 | 4.40 | 350 | 5.50 | 830 | 7.20 | 1,830 | 11.00 | 5,175 |
| 3.40 | 90 | 4.50 | 390 | 5.60 | 880 | 7.40 | 1,970 | 12.00 | 6,225 |
| 3.50 | 105 | 4.60 | 430 | 5.70 | 930 | 7.60 | 2,110 | 13.00 | 7,275 |
| 3.60 | 120 | 4.70 | 470 | 5.80 | 980 | 7.80 | 2,250 | 14.00 | 8,325 |
| 3.70 | 140 | 4.80 | 510 | 5.90 | 1,030 | 8.00 | 2,390 | | |
| 3.80 | 160 | 4.90 | 550 | 6.00 | 1,090 | 8.20 | 2,530 | | |
| 3.90 | 190 | 5.00 | 590 | 6.20 | 1,210 | 8.40 | 2,690 | | |
| 4.00 | 220 | 5.10 | 630 | 6.40 | 1,330 | 8.60 | 2,850 | | |

NOTE.—This table is based on 27 discharge measurements made during 1906, and is well defined between gage heights 3.7 feet and 14.3 feet.

*Monthly discharge of Mokelumne River near Clements, Cal., for 1906.*

[Drainage area, 642 square miles.]

| Month. | Discharge in second-feet. | | | Run-off. | | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Total in acre-feet. | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 6,960 | 55 | 996 | 61,200 | 1.55 | 1.79 |
| February | 2,000 | 350 | 808 | 44,900 | 1.26 | 1.31 |
| March | 7,750 | 880 | 2,520 | 155,000 | 3.92 | 4.52 |
| April | 5,380 | 2,110 | 2,940 | 175,000 | 4.57 | 5.10 |
| May | 6,750 | 2,730 | 4,700 | 289,000 | 7.32 | 8.44 |
| June | 8,740 | 3,580 | 6,020 | 358,000 | 9.38 | 10.46 |
| July | 7,480 | 730 | 3,540 | 218,000 | 5.51 | 6.35 |
| August | 680 | 160 | 356 | 21,900 | .554 | .64 |
| September | 350 | 150 | 202 | 12,000 | .315 | .35 |
| October | 235 | 140 | 190 | 11,700 | .296 | .34 |
| November | 655 | 120 | 248 | 14,800 | .386 | .43 |
| December | 4,960 | 150 | 876 | 53,900 | 1.36 | 1.57 |
| The year | 8,740 | 55 | 1,950 | 1,420,000 | 3.04 | 41.30 |

NOTE.—These values are excellent, except January to March, which are rated as good because the measurements made during that period give a discharge somewhat in excess of the rating.

# NORTHERN PACIFIC OCEAN DRAINAGE.

## KLAMATH RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Klamath River drains a large area in California and Oregon, lying between the basins of Sacramento River on the south, Deschutes and Rogue rivers on the north, and the minor streams of the Great Basin on the east. Its headwaters lie at elevations of from 7,000 to 9,000 feet. The region contains many flat valleys in which the soil is favorable to irrigation. Many of the streams flow through marshes, which are susceptible of drainage and cultivation. The water surface in the basin is large, comprising three large lakes and many smaller ones.

Link River rises in Upper Klamath Lake and flows through a large swamp area, feeding Lower Klamath Lake by overflow at high water and receiving water from the lake at low stages. Below Keno it is

known as Klamath River, and flows southwestward through Siskiyou, Humboldt, and Del Norte counties, in California emptying into the Pacific.

Important power possibilities exist on the stream, notably at Klamath Falls and at the rapids below Keno. Upper Klamath Lake is fed by Williamson River, and several smaller streams. Sycan River flows into Sprague River, a tributary of Williamson River.

Tule Lake lies just east of Lower Klamath Lake and has no surface outlet, but may have underground ones. Evaporation records at Keno indicate an annual loss of about 38 inches, while the rainfall and inflow amount to about 60 inches over the lake surface. The formation of the country is of a volcanic nature, showing many fissures where the rock is exposed, and this, together with the fact that many springs exist in the country to the southwest, tend to confirm the existence of such passages.

Lost River rises in Clear Lake and forms the principal supply of Tule Lake. Miller Creek enters Lost River from the east.

### LINK RIVER AT KLAMATH FALLS, OREG.[a]

This station was established May 15, 1904. It is located at the county bridge at Klamath Falls, Oreg., 1½ miles below the outlet of Klamath Lake. The conditions at this station and the bench marks are described in Water Supply Paper No. 177, page 226, where are given also references to publications that contain data for previous years.

*Discharge measurements of Link River at Klamath Falls, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 11 | L. F. Hendricks | 298 | 1,900 | 5.06 | 4,560 |
| June 20 | do | 290 | 1,650 | 4.65 | 3,400 |
| June 22 | Clapp and Hendricks | 290 | 1,650 | 4.65 | 3,640 |
| July 9 | L. F. Hendricks | 285 | 1,530 | 4.25 | 2,860 |
| July 24 | do | 280 | 1,420 | 3.80 | 2,190 |
| August 22 | do | 269 | 1,190 | 3.00 | 1,390 |
| December 20 | do | 279 | 1,310 | 3.48 | 2,050 |

*Daily gage height, in feet, of Link River at Klamath Falls, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.5 | 3.65 | 3.75 | 4.25 | 5.0 | 4.85 | 4.4 | 3.5 | 2.9 | 2.85 | 3.0 | 3.3 |
| 2 | 3.45 | 3.65 | 3.9 | 4.2 | 5.05 | 4.85 | 4.35 | 3.5 | 2.85 | 2.9 | 3.3 | 3.25 |
| 3 | 3.4 | 3.65 | 3.85 | 4.2 | 5.0 | 4.9 | 4.4 | 3.5 | 2.9 | 2.8 | 3.4 | 3.25 |
| 4 | 3.5 | 3.65 | 3.7 | 4.2 | 4.95 | 4.9 | 4.4 | 3.45 | 2.9 | 2.8 | [b]2.95 | 3.3 |
| 5 | 3.5 | 3.65 | 3.7 | 4.2 | 5.0 | 4.95 | 4.3 | 3.45 | 2.9 | 2.85 | 2.95 | 3.3 |
| 6 | 3.45 | 3.6 | 3.7 | 4.3 | 5.0 | 4.8 | 4.3 | 3.4 | 2.85 | [b]2.85 | 2.95 | 3.3 |
| 7 | 3.45 | 3.6 | 3.7 | 4.35 | 4.95 | 4.8 | 4.25 | 3.35 | 2.95 | [b]2.85 | 2.95 | 3.45 |
| 8 | 3.45 | 3.6 | 3.7 | 4.45 | 4.95 | 4.85 | 4.3 | 3.3 | 2.95 | 2.85 | 3.0 | 3.3 |
| 9 | 3.5 | 3.6 | 3.75 | 4.4 | 5.0 | 4.8 | 4.25 | 3.3 | [b]2.9 | 2.85 | 3.05 | [b]3.3 |
| 10 | 3.5 | 3.6 | 3.75 | 4.5 | 5.05 | 4.95 | 4.2 | 3.3 | 2.8 | 2.85 | 3.05 | 3.45 |

[a] This station was known as Klamath River at Klamath Falls, Oreg., in report for 1904.
[b] Estimated.

*Daily gage height, in feet, of Link River at Klamath Falls, Oreg., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 3.5 | 3.6 | 3.7 | 4.5 | 5.05 | 5.0 | 4.15 | 3.3 | 2.8 | 2.85 | 3.05 | 3.4 |
| 12 | 3.5 | 3.6 | 3.85 | 4.5 | 4.9 | 4.9 | 4.15 | 3.2 | 2.85 | 2.8 | 3.1 | 3.4 |
| 13 | 3.5 | 3.6 | 3.9 | 4.55 | 4.9 | 4.75 | 4.15 | 3.15 | 2.8 | 2.8 | 3.15 | 3.4 |
| 14 | 3.6 | 3.6 | 3.9 | 4.6 | 5.1 | 4.7 | 4.05 | 3.2 | 2.8 | 2.9 | 3.1 | 3.4 |
| 15 | 3.55 | 3.65 | 3.95 | 4.65 | 5.0 | 4.8 | 4.05 | 3.15 | 2.8 | 2.85 | 3.2 | 3.5 |
| 16 | 3.8 | 3.6 | 3.9 | 4.75 | 4.9 | 4.75 | 4.05 | 3.15 | 2.85 | 2.85 | 3.2 | 3.45 |
| 17 | 3.8 | 3.65 | 3.9 | 4.8 | 4.9 | 4.7 | 4.05 | 3.15 | 2.85 | 2.85 | 3.25 | 3.5 |
| 18 | 3.8 | 3.75 | 3.95 | 4.8 | 5.15 | 4.65 | 4.00 | 3.1 | 2.85 | 2.85 | 3.2 | 3.45 |
| 19 | 3.85 | 3.65 | 3.9 | 4.8 | 4.95 | 4.6 | 3.95 | 3.1 | 2.85 | 2.85 | 3.2 | 3.4 |
| 20 | 3.8 | 3.65 | 3.95 | 4.85 | 4.9 | 4.65 | 3.95 | 3.05 | 2.85 | 2.9 | 3.2 | 3.5 |
| 21 | 3.85 | 3.7 | 4.0 | 4.9 | 4.85 | 4.55 | 3.95 | 3.1 | 2.85 | 2.9 | 3.25 | 3.5 |
| 22 | 3.7 | 3.7 | 3.95 | 4.95 | 4.8 | 4.6 | 3.85 | 3.0 | 2.8 | 2.9 | 3.15 | 3.6 |
| 23 | 3.75 | 3.75 | 4.15 | 5.0 | 4.85 | 4.6 | 3.8 | 2.95 | 2.8 | 2.9 | 3.25 | a3.5 |
| 24 | 3.75 | 3.7 | 3.95 | 4.95 | 4.9 | 4.6 | 3.75 | 3.0 | 2.9 | 2.9 | 3.3 | 3.5 |
| 25 | 3.7 | 3.7 | 4.05 | 4.95 | 5.1 | 4.55 | 3.75 | 3.0 | 2.9 | 2.9 | a3.3 | a3.5 |
| 26 | 3.7 | 3.85 | 4.0 | 4.95 | 5.0 | 4.55 | 3.7 | 3.05 | 2.85 | 2.9 | 3.3 | 3.6 |
| 27 | 3.7 | 3.7 | 4.0 | 5.05 | 4.95 | 4.5 | 3.65 | 3.0 | 2.85 | 2.95 | 3.3 | 3.6 |
| 28 | 3.7 | 3.6 | 4.05 | 5.1 | 5.0 | 4.5 | 3.7 | 2.9 | 2.85 | 2.95 | 3.3 | 3.6 |
| 29 | 3.7 | ..... | 4.1 | 5.0 | 4.9 | 4.45 | 3.6 | 3.0 | 2.85 | 2.95 | 3.3 | 3.6 |
| 30 | 3.7 | ..... | 4.2 | 4.95 | 4.9 | 4.45 | 3.55 | 2.9 | 2.85 | 2.9 | 3.3 | 3.6 |
| 31 | 3.65 | ..... | 4.2 | ..... | 4.9 | ..... | 3.55 | 2.9 | ..... | 3.0 | ..... | 3.6 |

a Estimated.

*Rating table for Link River at Klamath Falls, Oreg., for 1904–1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.80 | 1,150 | 3.30 | 1,585 | 3.80 | 2,175 | 4.30 | 2,900 | 4.80 | 3,770 |
| 2.90 | 1,220 | 3.40 | 1,690 | 3.90 | 2,310 | 4.40 | 3,060 | 4.90 | 3,960 |
| 3.00 | 1,300 | 3.50 | 1,800 | 4.00 | 2,450 | 4.50 | 3,230 | 5.00 | 4,150 |
| 3.10 | 1,390 | 3.60 | 1,920 | 4.10 | 2,590 | 4.60 | 3,400 | 5.10 | 4,340 |
| 3.20 | 1,485 | 3.70 | 2,045 | 4.20 | 2,740 | 4.70 | 3,580 | 5.20 | 4,530 |

NOTE.—This table is based on discharge measurements made during 1904–1906 and is fairly well defined.

*Monthly discharge of Link River at Klamath Falls, Oreg., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 2,240 | 1,690 | 1,950 | 120,000 |
| February | 2,240 | 1,920 | 1,990 | 111,000 |
| March | 2,740 | 2,040 | 2,320 | 143,000 |
| April | 4,340 | 2,740 | 3,520 | 209,000 |
| May | 4,440 | 3,770 | 4,080 | 251,000 |
| June | 4,150 | 3,140 | 3,620 | 215,000 |
| July | 3,060 | 1,860 | 2,490 | 153,000 |
| August | 1,800 | 1,220 | 1,470 | 90,400 |
| September | 1,260 | 1,150 | 1,190 | 70,800 |
| October | 1,300 | 1,150 | 1,200 | 73,800 |
| November | 1,690 | 1,260 | 1,460 | 86,900 |
| December | 1,920 | 1,540 | 1,740 | 107,000 |
| The year | 4,440 | 1,150 | 2,250 | 1,630,000 |

NOTE.—These values are good.

## UPPER KLAMATH LAKE NEAR KLAMATH FALLS, OREG.

This station was established in January, 1906, for recording the water level in Upper Klamath Lake. It is located at the southeast end of the lake and above the upper riffle at the head of Link River.

The gage is a vertical timber, graduated to feet and tenths and fastened to posts driven in the lake bed a short distance from the shore of the lake.

On February 16, 1906, a Friez's automatic water-stage register was installed and the mean daily gage height record has been computed from its register sheets.

*Daily gage height, in feet, of Upper Klamath Lake at Klamath Falls, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | 5.30 | | 7.00 | 6.30 | 5.70 | 4.95 | 4.50 | 4.50 | 4.70 | 5.00 |
| 2 | | | 5.25 | | 6.80 | 6.20 | 5.75 | 4.90 | 4.55 | 4.65 | 4.30 | 4.90 |
| 3 | | | 5.35 | | 6.80 | 6.10 | 5.70 | 4.90 | 4.50 | 4.65 | 4.50 | 4.90 |
| 4 | | 5.21 | 5.35 | | 6.80 | 6.20 | 5.75 | 4.85 | 4.50 | 4.60 | 4.50 | 4.90 |
| 5 | | | 5.40 | | 6.70 | 6.30 | 5.70 | 4.90 | 4.50 | 4.55 | 4.60 | 4.90 |
| 6 | | | 5.40 | | 6.60 | 6.20 | 5.65 | 4.90 | 4.50 | 4.50 | 4.60 | 4.90 |
| 7 | 5.02 | | 5.40 | 6.15 | 6.50 | 6.20 | 5.60 | 4.90 | 4.35 | 4.50 | 4.70 | 4.90 |
| 8 | | | 5.40 | 6.10 | 6.50 | 6.10 | 5.65 | 4.90 | 4.50 | 4.50 | 4.80 | 4.90 |
| 9 | | | 5.40 | 6.20 | 6.40 | 6.20 | 5.60 | 4.80 | 4.60 | 4.50 | 4.80 | 4.95 |
| 10 | | | 5.51 | 6.40 | 6.30 | 5.90 | 5.55 | 4.75 | 4.65 | 4.50 | 4.80 | 4.80 |
| 11 | | 5.02 | | 6.40 | 6.60 | 5.70 | 5.50 | 4.70 | 4.55 | 4.50 | 4.85 | 5.00 |
| 12 | | | | 6.30 | 6.60 | 6.20 | 5.40 | 4.80 | 4.40 | 4.55 | 4.75 | 5.00 |
| 13 | | | | 6.40 | 6.40 | 6.20 | 5.45 | 4.70 | 4.60 | 4.50 | 4.90 | 5.00 |
| 14 | 5.10 | | | 6.50 | 6.20 | 6.10 | 5.40 | 4.75 | 4.65 | 4.55 | 4.85 | 5.00 |
| 15 | | | | 6.30 | 6.40 | 6.00 | 5.45 | 4.70 | 4.50 | 4.45 | 4.80 | 5.00 |
| 16 | | 5.20 | | 6.50 | 6.40 | 6.20 | 5.35 | 4.75 | 4.55 | 4.50 | 5.00 | 4.95 |
| 17 | | 5.20 | 5.50 | 6.50 | 6.30 | 6.10 | 5.35 | 4.70 | 4.50 | 4.65 | 5.30 | 5.00 |
| 18 | | 5.21 | 5.50 | 6.50 | 6.30 | 6.20 | 5.30 | 4.75 | 4.55 | 4.70 | 5.15 | 4.95 |
| 19 | | 5.21 | 5.50 | 6.50 | 6.40 | 6.20 | 5.25 | 4.70 | 4.55 | 4.80 | 5.95 | 5.00 |
| 20 | | 5.20 | 5.40 | 6.30 | 6.50 | 6.20 | 5.20 | 4.70 | 4.55 | 4.75 | 5.85 | 5.05 |
| 21 | 4.38 | 5.22 | 5.20 | 6.50 | 6.40 | 6.10 | 5.30 | 4.70 | 4.50 | 4.65 | 5.00 | 5.05 |
| 22 | | 5.23 | 5.20 | 6.60 | 6.30 | 6.10 | 5.20 | 4.60 | 4.35 | 4.60 | 5.15 | 5.00 |
| 23 | | 5.25 | 5.00 | 6.80 | 6.30 | 6.10 | 5.20 | 4.55 | 4.50 | 4.55 | 5.20 | 5.05 |
| 24 | | 5.26 | 5.52 | 6.70 | 6.10 | 6.00 | 5.15 | 4.50 | 4.55 | 4.55 | 5.05 | 5.10 |
| 25 | | 5.35 | 5.45 | 6.80 | 5.90 | 6.00 | 5.20 | 4.45 | 4.55 | 4.60 | 5.15 | 5.05 |
| 26 | | 5.35 | 5.50 | 6.70 | 6.20 | 6.05 | 5.15 | 4.55 | 4.55 | 4.55 | 5.15 | 5.10 |
| 27 | | 5.40 | 5.60 | 6.90 | 6.20 | 6.00 | 5.10 | 4.55 | 4.55 | 4.60 | 5.10 | 5.15 |
| 28 | 5.29 | 5.35 | 5.55 | 7.00 | 6.50 | 5.95 | 5.10 | 4.55 | 4.50 | 4.60 | 5.05 | 5.15 |
| 29 | | | 5.55 | 7.00 | 6.50 | 5.90 | 5.00 | 4.50 | 4.50 | 4.65 | 5.00 | 5.05 |
| 30 | | | 5.50 | 6.80 | 6.40 | 5.80 | 5.10 | 4.50 | 4.55 | 4.70 | 5.00 | 5.10 |
| 31 | | | 6.45 | | 6.40 | | 5.00 | 4.50 | | 4.75 | | 5.15 |

## KLAMATH RIVER AT KENO, OREG.

This station was established August 13, 1904. It is located one-fourth mile below the county bridge at Keno, Oreg. The conditions at this station and the bench marks are described in Water Supply Paper No. 177, page 229, where are given also references to publications that contain data for previous years.

*Discharge measurements of Klamath River at Keno, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 8 | L. F. Hendricks | 456 | 4,110 | 13.7 | 3,600 |
| June 30 | do | 430 | 3,840 | 13.4 | 3,330 |
| July 23 | do | 420 | 3,630 | 12.9 | 2,540 |
| September 5 | do | 405 | 3,300 | 12.05 | 1,170 |

*Daily gage height, in feet, of Klamath River at Keno, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12.5 | 12.8 | 12.8 | 13.1 | 13.6 | 13.7 | 13.4 | 12.6 | 12.1 | 12.0 | 12.2 | 12.4 |
| 2 | 12.5 | 12.8 | 12.9 | 13.1 | 13.6 | 13.7 | 13.4 | 12.6 | 12.1 | 12.0 | 12.2 | 12.4 |
| 3 | 12.5 | 12.8 | 12.9 | 13.1 | 13.6 | 13.7 | 13.4 | 12.6 | 12.1 | 12.0 | 12.2 | 12.5 |
| 4 | 12.5 | 12.8 | 12.8 | 13.1 | 13.7 | 13.7 | 13.3 | 12.6 | 12.1 | 12.0 | 12.2 | 12.5 |
| 5 | 12.5 | 12.8 | 12.8 | 13.1 | 13.7 | 13.7 | 13.3 | 12.6 | 12.1 | 12.0 | 12.2 | 12.5 |
| 6 | 12.5 | 12.8 | 12.8 | 13.2 | 13.7 | 13.7 | 13.3 | 12.6 | 12.1 | 12.0 | 12.2 | 12.5 |
| 7 | 12.5 | 12.8 | 12.8 | 13.2 | 13.7 | 13.7 | 13.3 | 12.5 | 12.1 | 12.0 | 12.2 | 12.5 |
| 8 | 12.5 | 12.7 | 12.8 | 13.2 | 13.7 | 13.7 | 13.3 | 12.5 | 12.1 | 12.0 | 12.2 | 12.5 |
| 9 | 12.5 | 12.7 | 12.8 | 13.2 | 13.7 | 13.7 | 13.3 | 12.5 | 12.1 | 12.0 | 12.2 | 12.5 |
| 10 | 12.5 | 12.7 | 12.8 | 13.2 | 13.7 | 13.7 | 13.2 | 12.5 | 12.1 | 12.0 | 12.2 | 12.5 |
| 11 | 12.4 | 12.7 | 12.8 | 13.3 | 13.7 | 13.7 | 13.2 | 12.5 | 12.1 | 12.0 | 12.2 | 12.5 |
| 12 | 12.5 | 12.7 | 12.8 | 13.3 | 13.7 | 13.6 | 13.2 | 12.5 | 12.0 | 12.0 | 12.3 | 12.5 |
| 13 | 12.6 | 12.7 | 12.8 | 13.3 | 13.7 | 13.6 | 13.2 | 12.5 | 12.0 | 12.0 | 12.3 | 12.5 |
| 14 | 12.7 | 12.7 | 12.8 | 13.3 | 13.7 | 13.6 | 13.2 | 12.4 | 12.0 | 12.0 | 12.3 | 12.5 |
| 15 | 12.6 | 12.7 | 12.9 | 13.3 | 13.7 | 13.6 | 13.2 | 12.4 | 12.0 | 12.0 | 12.3 | 12.5 |
| 16 | 12.7 | 12.7 | 12.9 | 13.4 | 13.7 | 13.6 | 13.2 | 12.4 | 12.0 | 12.0 | 12.3 | 12.5 |
| 17 | 12.7 | 12.7 | 12.9 | 13.4 | 13.7 | 13.6 | 13.1 | 12.3 | 12.0 | 12.0 | 12.3 | 12.6 |
| 18 | 12.7 | 12.7 | 12.9 | 13.4 | 13.7 | 13.6 | 13.1 | 12.3 | 12.0 | 12.0 | 12.3 | 12.6 |
| 19 | 12.8 | 12.7 | 12.9 | 13.5 | 13.7 | 13.6 | 13.1 | 12.3 | 12.0 | 12.0 | 12.4 | 12.6 |
| 20 | 12.8 | 12.7 | 12.9 | 13.5 | 13.7 | 13.5 | 13.1 | 12.3 | 12.0 | 12.1 | 12.4 | 12.6 |
| 21 | 12.8 | 12.7 | 12.9 | 13.5 | 13.7 | 13.5 | 13.1 | 12.3 | 12.0 | 12.1 | 12.4 | 12.6 |
| 22 | 12.8 | 12.8 | 12.9 | 13.5 | 13.7 | 13.5 | 13.0 | 12.2 | 12.0 | 12.1 | 12.4 | 12.7 |
| 23 | 12.8 | 12.8 | 12.9 | 13.5 | 13.7 | 13.5 | 12.9 | 12.2 | 12.0 | 12.1 | 12.4 | 12.6 |
| 24 | 12.8 | 12.8 | 12.9 | 13.5 | 13.7 | 13.5 | 12.9 | 12.2 | 12.0 | 12.1 | 12.4 | 12.6 |
| 25 | 12.8 | 12.8 | 13.0 | 13.5 | 13.7 | 13.5 | 12.8 | 12.2 | 12.0 | 12.1 | 12.4 | 12.6 |
| 26 | 12.8 | 12.8 | 13.0 | 13.5 | 13.7 | 13.5 | 12.8 | 12.2 | 12.0 | 12.1 | 12.4 | 12.6 |
| 27 | 12.8 | 12.8 | 13.0 | 13.6 | 13.7 | 13.5 | 12.8 | 12.2 | 12.0 | 12.1 | 12.4 | 12.6 |
| 28 | 12.8 | 12.8 | 13.0 | 13.6 | 13.7 | 13.4 | 12.8 | 12.2 | 12.0 | 12.1 | 12.4 | 12.6 |
| 29 | 12.8 | ..... | 13.0 | 13.6 | 13.7 | 13.4 | 12.7 | 12.2 | 12.0 | 12.1 | 12.4 | 12.6 |
| 30 | 12.8 | ..... | 13.0 | 13.6 | 13.7 | 13.4 | 12.7 | 12.2 | 12.0 | 12.1 | 12.4 | 12.7 |
| 31 | 12.8 | ..... | 13.0 | ..... | 13.7 | ..... | 12.7 | 12.1 | ..... | 12.2 | ..... | 12.7 |

*Rating table for Klamath River at Keno, Oreg., for 1904–1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 12.00 | 1,240 | 12.40 | 1,700 | 12.80 | 2,250 | 13.20 | 2,910 | 13.60 | 3,730 |
| 12.10 | 1,350 | 12.50 | 1,830 | 12.90 | 2,400 | 13.30 | 3,100 | 13.70 | 3,960 |
| 12.20 | 1,460 | 12.60 | 1,960 | 13.00 | 2,560 | 13.40 | 3,300 | | |
| 12.30 | 1,580 | 12.70 | 2,100 | 13.10 | 2,730 | 13.50 | 3,510 | | |

NOTE.—This table is based on discharge measurements made during 1904–1906 and is well defined.

*Monthly discharge of Klamath River at Keno, Oreg., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 2,250 | 1,700 | 2,050 | 126,000 |
| February | 2,250 | 2,100 | 2,180 | 121,000 |
| March | 2,560 | 2,250 | 2,380 | 146,000 |
| April | 3,730 | 2,730 | 3,220 | 192,000 |
| May | 3,960 | 3,730 | 3,940 | 242,000 |
| June | 3,960 | 3,300 | 3,710 | 221,000 |
| July | 3,300 | 2,100 | 2,750 | 169,000 |
| August | 1,960 | 1,350 | 1,680 | 103,000 |
| September | 1,350 | 1,240 | 1,280 | 76,200 |
| October | 1,460 | 1,240 | 1,290 | 79,300 |
| November | 1,700 | 1,460 | 1,580 | 94,000 |
| December | 2,100 | 1,700 | 1,900 | 117,000 |
| The year | 3,960 | 1,240 | 2,330 | 1,690,000 |

NOTE.—These values are excellent.

## SYCAN RIVER NEAR SILVERLAKE, OREG.

This station was established May 2, 1905, and discontinued October 12, 1905. It is located about 30 miles south of Silverlake, Oreg., in sec. 19, T. 32 S., R. 14 E. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 232.

*Discharge measurements of Sycan River near Silverlake, Oreg., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 16 | Ivan Landes | 21 | 27.6 | 2.40 | 38 |
| April 10 | do | 30 | 46.5 | 3.05 | 110 |
| May 2 | do | 56 | 92.6 | 3.45 | 193 |
| June 12 | do | 52 | 43.9 | 2.32 | 69 |
| July 30 | H. W. King | 19 | 11.9 | 1.27 | 10.2 |
| October 3 | Ivan Landes | 14 | 14.9 | 1.70 | 5.4 |
| November 7 | do | 12 | 7.1 | 1.12 | 6.0 |
| 1906. | | | | | |
| May 9 | Ivan Landes | 62 | 238 | 6.20 | 559 |
| May 31 | do | 59 | 167 | 4.80 | 344 |

*Daily discharge, in second-feet, of Sycan River near Silverlake, Oreg., for 1905.*

| Day. | May. | June. | July. | Aug. | Sept. | Oct. | Day. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 160 | 87 | 33 | 10 | 6 | 8 | 17 | 177 | 57 | 17 | 1 | 10 | 12 |
| 2 | 163 | 87 | 33 | 10 | 6 | 5 | 18 | 164 | 50 | 17 | 2 | 12 | 17 |
| 3 | 150 | 87 | 30 | 6 | 8 | 9 | 19 | 160 | 58 | 12 | 2 | 12 | 14 |
| 4 | 138 | 130 | 30 | 7 | 8 | 5 | 20 | 172 | 51 | 14 | 3 | 10 | 19 |
| 5 | 132 | 142 | 28 | 1 | 9 | 9 | 21 | 112 | 45 | 15 | 3 | 10 | 14 |
| 6 | 132 | 142 | 28 | 1 | 9 | 8 | 22 | 122 | 34 | 15 | 4 | 10 | 14 |
| 7 | 138 | 155 | 28 | 1 | 9 | 14 | 23 | 134 | 39 | 15 | 4 | 10 | 19 |
| 8 | 183 | 140 | 24 | 0 | 9 | 11 | 24 | 122 | 39 | 15 | 5 | 10 | 19 |
| 9 | 164 | 140 | 24 | 0 | 11 | 12 | 25 | 112 | 39 | 11 | 2 | 10 | 19 |
| 10 | 158 | 85 | 20 | 0 | 12 | 9 | 26 | 146 | 42 | 10 | 2 | 10 | 19 |
| 11 | 158 | 76 | 20 | 0 | 9 | 9 | 27 | 192 | 39 | 10 | 3 | 14 | 24 |
| 12 | 151 | 68 | 20 | 0 | 9 | 12 | 28 | 134 | 39 | 10 | 3 | 11 | 19 |
| 13 | 164 | 76 | 19 | 0 | 10 | 9 | 29 | 118 | 37 | 10 | 5 | 8 | 19 |
| 14 | 145 | 94 | 19 | 1 | 10 | 9 | 30 | 107 | 37 | 10 | 5 | 8 | 19 |
| 15 | 151 | 76 | 19 | 1 | 10 | 8 | 31 | 97 | ..... | 10 | 6 | ..... | 19 |
| 16 | 158 | 60 | 19 | 1 | 10 | 12 | | | | | | | |

NOTE.—These discharges were obtained by the indirect method for shifting channels.

*Monthly discharge of Sycan River near Silverlake, Oreg., for 1905.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| May | 192 | 97 | 146 | 8,980 |
| June | 155 | 34 | 75.0 | 4,460 |
| July | 33 | 10 | 18.9 | 1,160 |
| August | 10 | 0 | 2.87 | 176 |
| September | 14 | 6 | 9.67 | 575 |
| October | 24 | 5 | 13.4 | 824 |
| The period | | | | 16,200 |

NOTE.—These values are fair.

## LOST RIVER NEAR CLEAR LAKE, CAL.

This station was established September 1, 1904. It is located about 2 miles downstream from Jessie D. Carr's Clear Lake dam, a short distance below the dam site for Clear Lake reservoir, about 20 miles from Tule Lake post-office, Cal. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 233, where are given also references to publications that contain data for previous years.

*Discharge measurements of Lost River near Clear Lake, Cal., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 2 | C. T. Darley | 102 | 95 | 6.18 | 146 |
| March 3 | do | 102 | 93 | 6.25 | 157 |
| March 6 | do | 125 | 141 | 6.60 | 235 |
| March 7 | do | 127 | 203 | 7.18 | 452 |
| March 8 | do | 135 | 238 | 7.35 | 534 |
| March 9 | do | 126 | 204 | 7.18 | 460 |
| March 27 | do | 148 | 407 | 8.80 | 1,330 |
| April 3 | do | 150 | 421 | 9.00 | 1,480 |
| April 6 | do | 150 | 449 | 9.10 | 1,610 |
| April 17 | do | 148 | 376 | 8.50 | 1,270 |
| April 24 | L. F. Hendricks | 135 | 246 | 7.50 | 626 |
| May 2 | do | 125 | 168 | 6.90 | 365 |
| June 14 | do | 65 | 60 | 5.80 | 58 |
| July 15 | do | 10 | 10 | 5.20 | 13.9 |
| October 30 | do | 18 | 13 | 5.20 | 10.2 |

*Daily gage height, in feet, of Lost River near Clear Lake, Cal., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.2 | 5.5 | 6.45 | 9.3 | 6.95 | 6.45 | 5.25 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 |
| 2 | 5.2 | 5.5 | 6.15 | 9.1 | 6.85 | 6.3 | 5.2 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 |
| 3 | 5.2 | 5.5 | 6.2 | 9.0 | 6.8 | 6.3 | 5.2 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 |
| 4 | 5.2 | 5.5 | 6.15 | 9.0 | 6.75 | 6.3 | 5.1 | 5.1 | 5.1 | 5.2 | 5.3 | 5.3 |
| 5 | 5.2 | 5.5 | 6.2 | 9.05 | 6.5 | 6.3 | 5.05 | 5.1 | 5.1 | 5.2 | 5.3 | 5.3 |
| 6 | 5.2 | 5.5 | 6.55 | 9.1 | 6.45 | 6.4 | 5.0 | 5.1 | 5.1 | 5.2 | 5.3 | 5.3 |
| 7 | 5.2 | 5.5 | 7.1 | 9.25 | 6.4 | 6.6 | 5.0 | 5.1 | 5.1 | 5.2 | 5.3 | 5.3 |
| 8 | 5.2 | 5.5 | 7.25 | 9.3 | 6.35 | 6.55 | 5.0 | 5.1 | 5.1 | 5.2 | 5.3 | 5.3 |
| 9 | 5.2 | 5.5 | 7.2 | 9.4 | 6.3 | 6.45 | 5.0 | 5.1 | 5.1 | 5.2 | 5.3 | 5.3 |
| 10 | 5.2 | 5.5 | 7.4 | 9.4 | 6.25 | 6.2 | 5.0 | 5.1 | 5.1 | 5.2 | 5.3 | 5.35 |
| 11 | 5.3 | 5.5 | 7.8 | 9.3 | 6.25 | 6.2 | 5.3 | 5.1 | 5.1 | 5.2 | 5.3 | 5.4 |
| 12 | 5.3 | 5.5 | 7.75 | 9.3 | 6.2 | 6.1 | 5.25 | 5.1 | 5.1 | 5.2 | 5.3 | 5.45 |
| 13 | 5.3 | 5.5 | 7.75 | 9.2 | 6.2 | 6.1 | 5.2 | 5.1 | 5.2 | 5.2 | 5.3 | 5.45 |
| 14 | 5.4 | 5.5 | 7.75 | 9.0 | 6.2 | 6.0 | 5.2 | 5.1 | 5.2 | 5.2 | 5.3 | 5.5 |
| 15 | 5.4 | 5.75 | 7.75 | 8.75 | 6.2 | 5.9 | 5.2 | 5.1 | 5.2 | 5.2 | 5.3 | 5.5 |
| 16 | 5.5 | 5.85 | 7.75 | 8.5 | 6.2 | 5.85 | 5.2 | 5.1 | 5.2 | 5.2 | 5.3 | 5.5 |
| 17 | 5.55 | 5.8 | 7.75 | 8.4 | 6.2 | 5.85 | 5.2 | 5.1 | 5.2 | 5.2 | 5.3 | 5.6 |
| 18 | 5.55 | 5.8 | 7.85 | 8.2 | 6.2 | 5.8 | 5.2 | 5.1 | 5.2 | 5.2 | 5.3 | 5.6 |
| 19 | 5.55 | 6.0 | 8.0 | 8.0 | 6.1 | 5.7 | 5.15 | 5.1 | 5.2 | 5.2 | 5.3 | 5.7 |
| 20 | 5.55 | 6.7 | 8.1 | 7.8 | 6.1 | 5.6 | 5.15 | 5.1 | 5.2 | 5.2 | 5.3 | 5.7 |
| 21 | 5.55 | 6.8 | 8.2 | 7.7 | 6.05 | 5.5 | 5.15 | 5.1 | 5.2 | 5.2 | 5.3 | 5.8 |
| 22 | 5.55 | 6.85 | 8.3 | 7.65 | 6.05 | 5.5 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 | 5.8 |
| 23 | 5.55 | 6.55 | 8.4 | 7.55 | 6.05 | 5.4 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 | 5.8 |
| 24 | 5.5 | 6.25 | 8.5 | 7.55 | 6.0 | 5.35 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 | 6.15 |
| 25 | 5.5 | 6.0 | 8.7 | 7.4 | 6.0 | 5.3 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 | 6.8 |
| 26 | 5.5 | 6.2 | 8.8 | 7.25 | 6.0 | 5.4 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 | 7.2 |
| 27 | 5.5 | 6.9 | 8.8 | 7.2 | 6.2 | 5.45 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 | 7.35 |
| 28 | 5.5 | 6.6 | 8.8 | 7.1 | 6.4 | 5.35 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 | 7.3 |
| 29 | 5.5 | ..... | 8.75 | 7.0 | 6.5 | 5.35 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 | 7.15 |
| 30 | 5.5 | ..... | 8.8 | 7.0 | 6.6 | 5.35 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 | 7.0 |
| 31 | 5.5 | ..... | 9.3 | ..... | 6.6 | ..... | 5.1 | 5.1 | ..... | ..... | ..... | 7.0 |

*Rating table for Lost River near Clear Lake, Cal., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 5.00 | 5 | 5.80 | 66 | 6.60 | 252 | 7.40 | 562 | 8.40 | 1,100 |
| 5.10 | 8 | 5.90 | 81 | 6.70 | 286 | 7.50 | 608 | 8.60 | 1,230 |
| 5.20 | 12 | 6.00 | 98 | 6.80 | 320 | 7.60 | 654 | 8.80 | 1,360 |
| 5.30 | 17 | 6.10 | 118 | 6.90 | 356 | 7.70 | 702 | 9.00 | 1,500 |
| 5.40 | 23 | 6.20 | 140 | 7.00 | 392 | 7.80 | 755 | 9.20 | 1,640 |
| 5.50 | 30 | 6.30 | 164 | 7.10 | 432 | 7.90 | 810 | 9.40 | 1,785 |
| 5.60 | 40 | 6.40 | 191 | 7.20 | 474 | 8.00 | 865 | | |
| 5.70 | 52 | 6.50 | 220 | 7.30 | 518 | 8.20 | 980 | | |

NOTE.—This table is based on 15 discharge measurements made during 1906 and is well defined between gage heights 5.2 feet and 9.1 feet.

*Monthly discharge of Lost River near Clear Lake, Cal., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 35 | 12 | 23.6 | 1,450 |
| February | 356 | 30 | 106 | 5,890 |
| March | 1,710 | 129 | 797 | 49,000 |
| April | 1,780 | 392 | 1,150 | 68,400 |
| May | 374 | 98 | 177 | 10,900 |
| June | 252 | 17 | 99.2 | 5,900 |
| July | 17 | 5 | 9.4 | 578 |
| August | 8 | 8 | 8.0 | 492 |
| September | 12 | 8 | 10.4 | 619 |
| October | 12 | 12 | 12.0 | 738 |
| November | 17 | 12 | 16.5 | 982 |
| December | 540 | 17 | 127 | 7,810 |
| The year | 1,780 | 5 | 211 | 153,000 |

NOTE.—Values are rated as follows: March to May, excellent; August to November, fair; remainder of 1906, good.

## LOST RIVER NEAR MERRILL, OREG.

This station was established July 26, 1904. It is located about 1½ miles downstream from the Stukel Bridge, 4 miles northwest of Merrill, Oreg. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 236, where are given also references to publications that contain data for previous years.

*Discharge measurements of Lost River near Merrill, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 27 | C. T. Darley | 91 | 168 | 4.30 | 535 |
| March 25 | do | 130 | 908 | 10.75 | 2,620 |
| March 27 | R. Hubbard | 146 | 1,120 | 12.08 | 3,470 |
| March 27 | do | 146 | 1,140 | 12.22 | 3,570 |
| March 28 | do | 146 | 1,150 | 12.17 | 3,700 |
| March 28 | do | 145 | 1,110 | 12.06 | 3,530 |
| March 28 | do | 145 | 1,110 | 12.02 | 3,570 |
| March 29 | do | 144 | 1,090 | 11.62 | 3,510 |
| March 29 | do | 142 | 1,030 | 11.34 | 3,320 |
| March 30 | do | 142 | 970 | 11.04 | 3,080 |
| April 1 | do | 149 | 1,260 | 13.05 | 4,090 |
| April 1 | do | 149 | 1,270 | 13.18 | 4,190 |
| April 2 | do | 152 | 1,350 | 13.65 | 4,270 |
| April 2 | do | 152 | 1,350 | 13.66 | 4,560 |
| April 10 | C. T. Darley | 149 | 1,300 | 13.02 | 3,940 |
| April 13 | do | 145 | 1,100 | 11.92 | 3,160 |
| April 14 | do | 136 | 984 | 11.23 | 2,850 |
| April 18 | do | 138 | 824 | 9.80 | 2,360 |
| April 19 | do | 136 | 735 | 9.26 | 2,110 |
| April 20 | L. F. Hendricks | 132 | 563 | 8.32 | 1,320 |
| April 25 | C. T. Darley | 112 | 414 | 6.60 | 1,160 |
| April 26 | do | 112 | 406 | 6.50 | 1,110 |
| April 30 | L. F. Hendricks | 110 | 379 | 5.90 | 1,010 |
| May 5 | do | 105 | 241 | 4.80 | 563 |
| May 29 | do | 90 | 184 | 4.10 | 237 |
| June 19 | do | 92 | 146 | 3.98 | 217 |
| September 10 | do | 87 | 83 | 3.50 | 87 |

*Daily gage height, in feet, of Lost River near Merrill, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.3 | 3.3 | 4.55 | 12.9 | 5.6 | 4.45 | 3.7 | 3.55 | 3.5 | 3.5 | 3.4 | 3.4 |
| 2 | 3.3 | 3.3 | 5.2 | 13.6 | 5.3 | 4.45 | 3.7 | 3.55 | 3.5 | 3.5 | 3.4 | 3.4 |
| 3 | 3.3 | 3.3 | 5.0 | 12.7 | 5.05 | 4.5 | 3.7 | 3.55 | 3.5 | 3.5 | 3.4 | 3.4 |
| 4 | 3.3 | a 3.3 | 4.6 | 11.5 | 5.0 | 4.3 | 3.7 | 3.55 | 3.5 | 3.5 | 3.4 | 3.4 |
| 5 | 3.3 | a 3.3 | 4.35 | 10.6 | 4.85 | 4.3 | 3.7 | 3.55 | 3.5 | 3.5 | 3.4 | 3.4 |
| 6 | 3.3 | a 3.4 | 4.2 | 10.45 | 4.65 | 4.25 | 3.7 | 3.55 | 3.5 | 3.5 | 3.4 | 3.4 |
| 7 | 3.3 | 3.4 | 4.1 | 11.0 | 4.6 | 4.2 | 3.7 | 3.5 | 3.5 | 3.5 | 3.4 | 3.4 |
| 8 | 3.3 | 3.4 | 4.1 | 11.75 | 4.6 | 4.3 | 3.65 | 3.5 | 3.5 | 3.5 | 3.4 | 3.4 |
| 9 | 3.3 | 3.4 | 4.65 | 12.4 | 4.5 | 4.3 | 3.65 | 3.5 | 3.5 | 3.5 | 3.4 | 3.4 |
| 10 | 3.3 | 3.4 | 5.8 | 13.0 | 4.45 | 4.3 | 3.6 | 3.5 | 3.5 | 3.5 | 3.4 | 3.4 |
| 11 | 3.3 | 3.4 | 6.3 | 13.5 | 4.35 | 4.4 | 3.6 | 3.5 | 3.5 | 3.5 | 3.4 | 3.4 |
| 12 | 3.3 | 3.4 | 6.7 | 13.05 | 4.25 | 4.15 | 3.7 | 3.5 | 3.5 | 3.5 | 3.4 | 3.45 |
| 13 | 3.3 | 3.4 | 5.85 | 12.1 | 4.2 | 4.15 | 3.7 | 3.55 | 3.5 | 3.5 | 3.4 | 3.45 |
| 14 | 3.3 | 3.45 | 5.5 | 11.2 | 4.3 | 4.1 | 3.6 | 3.55 | 3.5 | 3.5 | 3.4 | 3.45 |
| 15 | 3.3 | 3.45 | 5.9 | 10.55 | 4.2 | 4.2 | 3.6 | 3.55 | 3.5 | 3.5 | 3.4 | 3.45 |
| 16 | 3.3 | 3.5 | 5.2 | 10.1 | 4.15 | 4.2 | 3.6 | 3.5 | 3.5 | 3.5 | 3.4 | 3.45 |
| 17 | 3.3 | 3.5 | 4.9 | 9.95 | 4.2 | 4.0 | 3.6 | 3.55 | 3.5 | 3.5 | 3.4 | 3.45 |
| 18 | 3.3 | 3.6 | 4.5 | 9.9 | 4.25 | 3.9 | 3.6 | 3.55 | 3.5 | 3.5 | 3.4 | 3.45 |
| 19 | 3.3 | 3.8 | 4.4 | 9.25 | 4.15 | 3.95 | 3.6 | 3.55 | 3.5 | 3.5 | 3.4 | 3.45 |
| 20 | 3.3 | 4.0 | 4.35 | 8.45 | 4.05 | 3.85 | 3.6 | 3.55 | 3.5 | 3.5 | 3.4 | 3.45 |
| 21 | 3.3 | 4.45 | 4.45 | 7.95 | 4.1 | 3.85 | 3.6 | 3.55 | 3.5 | 3.5 | 3.4 | 3.45 |
| 22 | 3.3 | 5.15 | 4.75 | 7.4 | 4.05 | 3.8 | 3.6 | 3.5 | 3.5 | 3.5 | 3.4 | 3.45 |
| 23 | 3.3 | 5.2 | 5.5 | 7.1 | 4.1 | 3.85 | 3.6 | 3.5 | 3.5 | 3.5 | 3.4 | 3.45 |
| 24 | 3.3 | 5.3 | 8.9 | 6.85 | 4.0 | 3.85 | 3.55 | 3.55 | 3.5 | 3.5 | 3.4 | 3.45 |
| 25 | 3.3 | 4.9 | 10.8 | 6.6 | 4.2 | 3.8 | 3.55 | 3.55 | 3.5 | 3.5 | 3.4 | 3.5 |
| 26 | 3.3 | 4.5 | 11.4 | 6.5 | 4.1 | 3.8 | 3.55 | 3.55 | 3.5 | 3.5 | 3.4 | 3.5 |
| 27 | 3.3 | 4.3 | 12.1 | 6.5 | 4.05 | 3.8 | 3.55 | 3.55 | 3.5 | 3.5 | 3.4 | 3.65 |
| 28 | 3.3 | 4.3 | 12.1 | 6.25 | 4.05 | 3.8 | 3.55 | 3.55 | 3.5 | 3.5 | 3.4 | 4.85 |
| 29 | 3.3 | ..... | 11.5 | 5.85 | 4.1 | 3.7 | 3.55 | 3.5 | 3.5 | 3.5 | 3.4 | 5.6 |
| 30 | 3.3 | ..... | 11.05 | 5.9 | 4.15 | 3.7 | 3.55 | 3.5 | 3.5 | 3.5 | 3.4 | 5.2 |
| 31 | 3.3 | ..... | 11.5 | ..... | 4.25 | ..... | 3.55 | 3.5 | ..... | 3.5 | ..... | 4.8 |

a Estimated.

*Rating tables for Lost River near Merrill, Oreg.*

JANUARY 1 TO MAY 17, 1906.a

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.30 | 102 | 4.50 | 467 | 5.70 | 887 | 6.80 | 1,272 | 8.80 | 2,006 |
| 3.40 | 125 | 4.60 | 502 | 5.80 | 922 | 6.90 | 1,307 | 9.00 | 2,080 |
| 3.50 | 150 | 4.70 | 537 | 5.90 | 957 | 7.00 | 1,342 | 9.20 | 2,160 |
| 3.60 | 176 | 4.80 | 572 | 6.00 | 992 | 7.20 | 1,414 | 9.40 | 2,240 |
| 3.70 | 203 | 4.90 | 607 | 6.10 | 1,027 | 7.40 | 1,488 | 9.60 | 2,320 |
| 3.80 | 232 | 5.00 | 642 | 6.20 | 1,062 | 7.60 | 1,562 | 9.80 | 2,400 |
| 3.90 | 262 | 5.10 | 677 | 6.30 | 1,097 | 7.80 | 1,636 | 10.00 | 2,480 |
| 4.00 | 294 | 5.20 | 712 | 6.40 | 1,132 | 8.00 | 1,710 | 11.00 | 2,930 |
| 4.10 | 328 | 5.30 | 747 | 6.50 | 1,167 | 8.20 | 1,784 | 12.00 | 3,440 |
| 4.20 | 362 | 5.40 | 782 | 6.60 | 1,202 | 8.40 | 1,858 | 13.00 | 4,000 |
| 4.30 | 397 | 5.50 | 817 | 6.70 | 1,237 | 8.60 | 1,932 | 14.00 | 4,630 |
| 4.40 | 432 | 5.60 | 852 | | | | | | |

MAY 18 TO DECEMBER 31, 1906.b

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3.40 | 66 | 3.90 | 185 | 4.40 | 342 | 4.90 | 511 | 5.30 | 650 |
| 3.50 | 87 | 4.00 | 215 | 4.50 | 375 | 5.00 | 545 | 5.40 | 685 |
| 3.60 | 108 | 4.10 | 246 | 4.60 | 409 | 5.10 | 580 | 5.50 | 720 |
| 3.70 | 131 | 4.20 | 278 | 4.70 | 443 | 5.20 | 615 | 5.60 | 755 |
| 3.80 | 157 | 4.30 | 310 | 4.80 | 477 | | | | |

a This table is based on discharge measurements made during 1904–1906 and is well defined.
b This table is based on 3 discharge measurements made during 1906 and is well defined between gage heights 3.5 feet and 4.1 feet.

*Monthly discharge of Lost River near Merrill, Oreg., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 102 | 102 | 102 | 6,270 |
| February | 747 | 102 | 259 | 14,400 |
| March | 3,500 | 328 | 1,260 | 77,500 |
| April | 4,380 | 940 | 2,540 | 151,000 |
| May | 852 | 215 | 386 | 23,700 |
| June | 375 | 131 | 240 | 14,300 |
| July | 131 | 98 | 113 | 6,950 |
| August | 98 | 87 | 93.7 | 5,760 |
| September | 87 | 87 | 87.0 | 5,180 |
| October | 87 | 87 | 87.0 | 5,350 |
| November | 66 | 66 | 66.0 | 3,930 |
| December | 755 | 66 | 130 | 7,990 |
| The year | 4,380 | 66 | 447 | 186,400 |

NOTE.—These values are excellent except for May, which is good.

## TULE LAKE NEAR MERRILL, OREG.

This station was established May 17, 1904, for recording the water level in Tule Lake. It is located on Tule Lake at the mouth of Lost River about 3 miles east of Merrill, Oreg., 25 miles south from Klamath Falls, and near the Oregon-California line. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 238.

*Daily gage height, in feet, of Tule Lake near Merrill, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | 7.75 | | 9.0 | 8.85 | 8.4 | 7.75 | 7.4 | 7.15 | 7.0 |
| 2 | | 6.65 | 6.8 | | | | | | | | | |
| 5 | 6.5 | | | | | | | | | | | |
| 7 | | | | 8.4 | | | | | 7.7 | | | |
| 8 | | | | | 9.1 | | | 8.2 | | | | 7.1 |
| 9 | | 6.65 | 6.95 | | | 9.0 | 8.8 | | | 7.3 | | |
| 10 | | | | | | | | | | | 7.15 | |
| 11 | 6.5 | | | | | | | | | | | |
| 13 | | | | | | 9.0 | | | | | | |
| 15 | | | | | | | | | 7.6 | | | |
| 16 | | | 7.1 | 8.85 | 9.1 | | 8.7 | 8.05 | | | | |
| 18 | | | | | | | | | | | | 7.25 |
| 19 | | | | | | | | | | 7.2 | | |
| 20 | | | | | | | | | | | 7.15 | |
| 21 | | | | | | 8.9 | | | | | | |
| 22 | | | | 9.0 | | | | 7.85 | 7.5 | | | |
| 23 | 6.7 | | | | | | 8.45 | | | | | |
| 24 | | | 7.3 | | 9.05 | | | | | | | |
| 25 | | | 7.3 | | | | | | | | | 7.3 |
| 28 | | | | | | | | 7.8 | | | | |
| 30 | | | 7.7 | 9.1 | | 8.85 | 8.4 | | 7.4 | | 7.0 | |
| 31 | | | | | 9.0 | | | 7.8 | | 7.15 | | 7.35 |

## MILLER CREEK NEAR LORELLA, OREG.

This station was established August 10, 1904. It is located at the Horsefly dam site, 10 miles northeast of Lorella, Oreg. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 239, where are given also references to publications that contain data for previous years.

*Discharge measurements of Miller Creek near Lorella, Oreg., by L. F. Hendricks, in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 27 | 140 | 225 | 8.65 | 883 | April 6 | 140 | 298 | 9.28 | 1,240 |
| March 28[a] | 140 | 243 | 8.65 | 884 | April 9 | 160 | 517 | 10.65 | 2,550 |
| March 29 | 140 | 271 | 8.80 | 1,040 | April 10 | 150 | 389 | 9.72 | 1,690 |
| March 30 | 140 | 340 | 9.50 | 1,440 | April 22 | 125 | 127 | 7.55 | 308 |
| March 30 | 150 | 431 | 10.10 | 1,940 | April 25 | 130 | 129 | 7.62 | 309 |
| April 4 | 140 | 188 | 8.25 | 629 | July 14 | | | 5.80 | 0 |
| April 5 | 140 | 284 | 9.00 | 1,110 | | | | | |

[a] Measured by C. T. Darley.

*Daily gage height, in feet, of Miller Creek near Lorella, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.2 | 6.3 | 7.0 | 8.1 | 7.0 | 7.2 | 6.15 | | 6.1 |
| 2 | 6.2 | 6.3 | 7.1 | 8.1 | 7.0 | 7.0 | 6.15 | | 6.1 |
| 3 | 6.2 | 6.3 | 7.1 | 8.4 | 6.9 | 6.9 | 6.1 | | 6.1 |
| 4 | 6.2 | 6.3 | 7.05 | 8.15 | 6.8 | 6.9 | 6.1 | | 6.1 |
| 5 | 6.2 | 6.3 | 7.0 | 9.2 | 6.7 | 7.0 | 6.05 | | 6.2 |
| 6 | 6.2 | 6.3 | 7.05 | 9.5 | 6.7 | 7.3 | 6.05 | | 6.2 |
| 7 | 6.3 | 6.3 | 7.2 | 9.9 | 6.7 | 7.2 | 6.0 | | 6.35 |
| 8 | 6.3 | 6.3 | 7.5 | 9.9 | 6.6 | 7.2 | 6.0 | | 6.4 |
| 9 | 6.4 | 6.3 | 7.7 | 10.5 | 6.6 | 7.1 | | | 6.3 |
| 10 | 6.4 | 6.3 | 7.8 | 10.0 | 6.5 | 7.0 | | | 6.3 |
| 11 | 6.4 | 6.3 | 7.7 | 9.1 | 6.5 | 6.9 | | | 6.3 |
| 12 | 6.3 | 6.3 | 7.6 | 8.8 | 6.5 | 6.8 | | | 6.2 |
| 13 | 6.3 | 6.3 | 7.5 | 8.8 | 6.6 | 6.8 | | | 6.2 |
| 14 | 6.3 | 6.3 | 7.3 | 8.7 | 6.7 | 6.7 | | | 6.2 |
| 15 | 6.3 | 6.3 | 7.1 | 8.7 | 6.7 | 6.6 | | | 6.2 |
| 16 | 6.3 | 6.3 | 6.9 | 8.9 | 6.7 | 6.5 | | | 6.2 |
| 17 | 6.3 | 6.3 | 6.7 | 8.5 | 6.7 | 6.5 | | | 6.2 |
| 18 | 6.3 | 6.3 | 6.7 | 8.1 | 6.6 | 6.4 | | 6.1 | 6.2 |
| 19 | 6.3 | 6.3 | 6.7 | 7.9 | 6.6 | 6.4 | | 6.1 | 6.2 |
| 20 | 6.3 | 6.3 | 6.7 | 7.8 | 6.5 | 6.3 | | 6.1 | 6.25 |
| 21 | 6.3 | 6.3 | 7.2 | 7.7 | 6.5 | 6.3 | | 6.1 | 6.3 |
| 22 | 6.3 | 6.3 | 7.8 | 7.5 | 6.5 | 6.2 | | 6.1 | 6.3 |
| 23 | 6.3 | 6.3 | 8.3 | 7.5 | 6.5 | 6.2 | | 6.1 | 6.4 |
| 24 | 6.3 | 6.2 | 8.8 | 7.4 | 6.5 | 6.1 | | 6.1 | 6.6 |
| 25 | 6.3 | 6.4 | 9.7 | 7.5 | 6.4 | 6.1 | | 6.1 | 7.65 |
| 26 | 6.3 | 6.6 | 9.0 | 7.4 | 6.5 | 6.1 | | 6.1 | 8.35 |
| 27 | 6.3 | 6.7 | 8.6 | 7.3 | 6.8 | 6.1 | | 6.1 | 7.95 |
| 28 | 6.3 | 6.8 | 8.65 | 7.4 | 7.1 | 6.15 | | 6.1 | 7.4 |
| 29 | 6.3 | | 8.65 | 7.4 | 7.5 | 6.15 | | 6.1 | 7.4 |
| 30 | 6.3 | | 9.7 | 7.2 | 7.5 | 6.15 | | 6.1 | 6.8 |
| 31 | 6.3 | | 9.6 | | 7.4 | | | | 6.6 |

NOTE.—The creek was dry July 7 to November 17.

*Rating table for Miller Creek near Lorella, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 6.00 | 0 | 6.80 | 52 | 7.60 | 290 | 8.40 | 715 | 9.40 | 1,415 |
| 6.10 | 1.5 | 6.90 | 67 | 7.70 | 337 | 8.50 | 775 | 9.60 | 1,575 |
| 6.20 | 4 | 7.00 | 86 | 7.80 | 387 | 8.60 | 835 | 9.80 | 1,745 |
| 6.30 | 8 | 7.10 | 109 | 7.90 | 437 | 8.70 | 900 | 10.00 | 1,915 |
| 6.40 | 13 | 7.20 | 136 | 8.00 | 490 | 8.80 | 965 | 10.20 | 2,085 |
| 6.50 | 20 | 7.30 | 168 | 8.10 | 545 | 8.90 | 1,035 | 10.40 | 2,265 |
| 6.60 | 29 | 7.40 | 205 | 8.20 | 600 | 9.00 | 1,110 | | |
| 6.70 | 39 | 7.50 | 245 | 8.30 | 655 | 9.20 | 1,260 | | |

NOTE.—This table is based on discharge measurements made during 1904–1906 and is well defined.

*Monthly discharge of Miller Creek near Lorella, Oreg., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 13 | 4 | 7.7 | 474 |
| February | 52 | 4 | 11.5 | 639 |
| March | 1,660 | 39 | 445 | 27,400 |
| April | 2,360 | 136 | 779 | 46,400 |
| May | 245 | 13 | 56.7 | 3,490 |
| June | 168 | 1.5 | 47.3 | 2,810 |
| July | 2.8 | 0 | 0.3 | 18 |
| August | 0 | 0 | 0 | 0 |
| September | 0 | 0 | 0 | 0 |
| October | 0 | 0 | 0 | 0 |
| November | 1.5 | 0 | 0.6 | 36 |
| December | 685 | 1.5 | 68.1 | 4,190 |
| The year | 2,360 | 0 | 118 | 85,500 |

NOTE.—Values are rated as follows: March to May and December, excellent; January, February, and June, good; July and November, fair.

MISCELLANEOUS MEASUREMENTS IN KLAMATH RIVER DRAINAGE BASIN.

*Cherry Creek (North Fork) near Crystal, Oreg.*—This stream is tributary to Upper Klamath Lake from the west. A measurement was made September 1, 1906, near the crossing on the road from Fort Klamath to Pelican Bay:

Width, 9.5 feet; area, 5.8 square feet; discharge, 9.4 second-feet.

*Cottonwood Creek near Brownell, Cal.*—Cottonwood Creek is tributary to Lower Klamath Lake from the south. The following measurements were made during 1906 at Brownell's "F" ranch:

February 13: Width, 22 feet; area, 25 square feet; discharge, 14 second-feet.
September 26: Width, 25 feet; area, 32 square feet; discharge, 12.2 second-feet.

*Crooked Creek near Klamath Agency, Oreg.*—This stream is a tributary of Wood River. A measurement was made August 31, 1906, at the bridge 1½ miles from Klamath Agency on the road to Fort Klamath:

Width, 31 feet; area, 94 square feet; discharge, 59 second-feet.

*Doris Creek near Doris, Cal.*—Doris Creek is tributary to Lower Klamath Lake from the southwest. The following measurements were made during 1906 at Doris ranch:

March 22: Width, 5.4 feet; area, 7.4 square feet; discharge, 11.6 second-feet.
February 14: Width, 5.5 feet; area, 5.1 square feet; discharge, 8 second-feet.
September 26: Width, 13 feet; area, 13.7 square feet; discharge, 8.4 second-feet.

*Fort Creek near Fort Klamath, Oreg.*—This stream is a tributary of Wood River. A measurement was made August 31, 1906, at the bridge 2 miles southeast from Fort Klamath on the road between Klamath Agency and Fort Klamath:

Width, 42 feet; area, 104 square feet; discharge, 115 second-feet.

*Rock Creek near Odessa, Oreg.*—This stream is tributary to Upper Klamath Lake from the west. A measurement was made September 3, 1906, at road crossing 7 miles below Odessa on the road from Odessa to Klamath Falls:

Width, 14 feet; area, 9.8 square feet; discharge, 12.8 second-feet.

*Sevenmile Creek near Fort Klamath, Oreg.*—This creek is tributary to Upper Klamath Lake. A measurement was made September 1, 1906, at the bridge on the road between Fort Klamath and Pelican Bay:

Width, 29 feet; area, 99 square feet; discharge, 83 second-feet.

*Spring Creek near Klamath Agency, Oreg.*—This stream is a small tributary of Crooked Creek. A measurement was made August 31, 1906, at the bridge 1 mile from Klamath Agency on the road to Fort Klamath:

Width, 22 feet; area, 42 square feet; discharge, 27 second-feet.

*Willow Creek near Brownell, Cal.*—Willow Creek is tributary to Lower Klamath Lake from the south. The following measurements were made during 1906 near the bridge on the Merrill and Brownell road:

February 13: Width, 18 feet; area, 13 square feet; discharge, 13 second-feet.
March 24: Width, 20.5 feet; area, 15.5 square feet; discharge, 17.2 second-feet.
September 26: Width, 35 feet; area, 26 square feet; discharge, 13 second-feet.

*Wood River near Fort Klamath, Oreg.*—Wood River is tributary to Upper Klamath Lake from the north. The following measurements were made August 30, 1906, at the bridge at Fort Klamath, Oreg.:

Width, 54 feet; area, 175 square feet; discharge, 257 second-feet.

At the bridge on the county road 4 miles below Fort Klamath, Oreg.:

Width, 55 feet; area, 313 square feet; discharge, 462 second-feet.

*Williamson River near Klamath Agency, Oreg.*—This stream is tributary to Upper Klamath Lake from the north. A measurement was made August 29 at the bridge on the county road between Klamath Falls and Fort Klamath, Oreg.:

Width, 162 feet; area, 1,348 square feet; discharge, 880 second-feet.

## PRECIPITATION AND EVAPORATION DATA.

The following table gives the total precipitation and evaporation in inches, by months, and also the annual totals, for 1906:

*Precipitation and evaporation in Klamath River basin.*

PRECIPITATION.

| | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keno, Oreg..... | 6.94 | 1.40 | 2.94 | 0.67 | 2.33 | 1.18 | 1.26 | 0.14 | 0.66 | 0.89 | 1.90 | 2.79 | 23.10 |
| Clear Lake, Oreg. | 4.00 | 2.07 | 3.62 | .09 | 2.7 | 1.05 | .60 | .00 | .76 | .41 | 2.05 | 3.70 | .21.05 |
| Horse-fly, near Lorella, Oreg .. | 9.47 | 4.00 | 6.65 | .52 | 1.88 | 1.45 | .00 | .00 | .67 | ..... | ..... | ..... | ..... |

EVAPORATION.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keno, Oreg..... | (a) | (a) | (a) | 3.03 | 4.58 | 4.04 | 5.87 | 4.69 | b3.27 | 2.22 | (a) | (a) | ..... |

a Wind and ice destroys record.

b October 1 to 27, inclusive.

# FLUCTUATIONS IN GROUND-WATER LEVELS IN THE VALLEY OF SOUTHERN CALIFORNIA.

By W. C. Mendenhall.

In the summer of 1903 the United States Geological Survey undertook a systematic study of the occurrence, distribution, and proper use of the ground waters in the valley of southern California. During the preceding decade the underground waters of this part of California had been extensively drawn on as a source of supply for irrigation and for municipal use. Many independent enterprises were established which depended entirely on them, while older systems dependent in the beginning on gravity waters had found it necessary to augment their supply by utilizing subsurface waters. As a result of all this development—greater in the citrus regions, where the large values of the products raised by irrigation made it possible to pay high prices for water; somewhat less in the lower lands, suitable only for the cultivation of alfalfa or other farm products, which yield less profits than those from the horticultural lands—marked effects were produced on ground-water levels and on the yield of wells. It became evident, therefore, that any thorough study of conditions controlling the proper use of ground waters should involve the consideration of definite evidence as to their fluctuations and as to the relation of the fluctuations to development on the one hand and to the supply derived from annual rainfall on the other. During the decade of dry years which preceded 1903 it was evident that artesian areas had decreased, that the flow of individual wells had lessened, and that ground-water levels had been generally lowered; but definite observations as to the amount of these shrinkages for comparison with rainfall records were lacking except for a few wells. The Riverside Trust Company, the present owners of the Gage canal system and of the wells from which its water supplies are drawn, had maintained since 1892 a series of systematic measurements of variations of water level in the Williams well on the Victoria tract, and Mr. J. B. Neff,

of Anaheim, had maintained a similar series of measurements since 1898. Here and there throughout the valley of southern California scattered data were found bearing on the problem, but only in these two localities had systematic and continuous observations been made.

Because the ground waters of southern California occur not in one great basin but in a series of more or less completely separated subterranean reservoirs, the supply in each being dependent upon the relation between local development and local tributary rainfall, general conclusions that were applicable everywhere could not safely be based on the records furnished by the Williams and Neff wells. It was therefore decided, in the autumn of 1904, to begin an independent series of measurements in wells so selected that they would be evenly distributed over the various basins which together make up the lowland areas of southern California and would thus give an adequate basis for conclusions as to conditions in each of these basins. For this purpose a number of wells were selected in localities distributed from Santa Monica to San Bernardino and San Jacinto. The attempt was made to select wells in each of the important local ground-water districts which would adequately represent the various conditions that exist in each of these districts. Wells have been selected which are close to the larger river beds and therefore fluctuate rapidly through a wide range with flood-water and low-water periods, and other wells have been selected which are remote from these local sources of supply and which on this account exhibit comparatively minor variations. Some of these observation wells are situated in the vicinity of groups of large pumping plants; others are at points which are comparatively remote from these centers of great development, while still others were so selected as to form a series, like that in the El Monte basin, extending back from a stream channel, the line of most effective recharge, thereby enabling the student of ground-water supplies to trace the percolation wave and observe its diminishing intensity and amplitude as it advances from its point of origin. It is believed, therefore, that practically all conditions are well represented in the measurements which have been obtained.

At the time of the beginning of these measurements southern California was near the end of a long period of low rainfall, during which ground-water levels had materially declined. Since the beginning of measurements, however, there have been two winters in which the rainfall reached from 20 to 30 per cent above the average, and the present winter—that of 1906–7—it seems, will maintain this high average. Under these conditions, since ground waters are dependent as absolutely if not as obviously on rainfall as are surface waters, there should be a marked and general rise of the ground-water plane

if withdrawals are not in excess of the average annual restoration. Under conservative use of these waters the ground-water levels will decline during the dry periods but will recover correspondingly during the wet years. Continuous declines during seasons of excessive precipitation mean overuse.

A few of the results of these measurements have been discussed in Water-Supply Paper No. 218, which treats of ground-water conditions in the foothill belt only; but in order that all the observations made may be available for engineers and others who are interested in ground-water problems in southern California, they are more fully presented in the tables that follow.

A simple black and white index map (Pl. IV), on which the location of each record well is shown, accompanies the tables. On this map the wells are numbered, and corresponding numbers are given each record.

In order to facilitate still further the identification of the wells the name of the owner of nearly everyone of them is given, as well as the approximate position of each in relation to a near-by town.

*Tables showing variations of water level in wells in southern California.*

1. R. Kidson, ¾ mile NE. of Slauson.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1905. | |
| Jan. 3 | 44 1 |
| Feb. 6 | 44 6 |
| Mar. 14 | 44 4 |
| Apr. 10 | 44 1 |
| June 9 | 44 4 |
| July 10 | 44 9 |
| Aug. 8 | 45 3 |
| Sept. 11 | 45 11 |
| Nov. 3 | 46 2 |
| Dec. 14 | 45 10 |
| 1906. | |
| Jan 22 | 46 10 |
| Mar. 19 | 47 7½ |
| May 2 | 44 11 |
| June 21 | 47 10 |
| July 27 | 46 2 |
| Sept. 17 | 46 6½ |
| Dec. 14 | 46 8 |

2. Chinese gardeners, ½ mile SW. of Slauson.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 1 | 25 2½ |
| Oct. 3 | 22 4½ |
| Nov. 4 | 22 7½ |
| Dec. 6 | 22 2 |
| 1905. | |
| Jan. 3 | 21 10 |
| Feb. 6 | 21 9 |
| Mar. 14 | 21 1½ |
| Apr. 10 | 20 5 |
| May 3 | 20 5 |
| June 10 | 24 6 |
| July 10 | 23 0 |
| Aug. 8 | 24 0 |
| Sept. 11 | 24 7 |
| Nov. 3 | 23 6 |
| Dec. 14 | 23 ½ |
| 1906. | |
| Jan. 22 | 22 6 |
| Mar. 19 | 22 1 |
| June 21 | 23 6½ |
| May 2 | 23 1 |
| July 27 | 24 ½ |
| Sept. 17 | 25 3 |
| Dec. 14 | 23 8½ |

3. Eliza Connelly, 1½ miles N. of Sunnyside.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1905. | |
| Jan. 3 | 22 5 |
| Feb. 6 | 22 6 |
| Mar. 14 | 21 11 |
| Apr. 10 | 21 6 |
| May 3 | 21 5 |
| June 9 | 22 7½ |
| July 10 | 23 6 |
| Nov. 3 | 23 10 |
| Dec. 14 | 23 ½ |
| 1906. | |
| Mar. 19 | 22 6 |
| May 2 | 22 7½ |
| June 21 | 23 9½ |
| Sept. 17 | 24 4½ |
| Dec. 14 | 23 7 |

*Tables showing variations of water level in wells in southern California*—Continued.

4. Mr. Till, 2½ miles S. of Slauson.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Sept. 1 | 29 10 |
| Oct. 3 | 32 1½ |
| Dec. 6 | 31 11 |
| 1905. | |
| Jan. 2 | 29 7 |
| Feb. 6 | 29 6 |
| Mar. 14 | 29 1 |
| Apr. 10 | 28 7 |
| May 3 | 28 8 |
| June 9 | 29 4 |
| July 10 | 29 5 |
| Aug. 8 | 30 1 |
| Sept. 11 | 30 6 |
| Nov. 3 | 30 6 |
| Dec. 14 | 30 6 |
| 1906. | |
| Jan. 22 | 30 5 |
| Mar. 19 | 30 7½ |
| May 2 | 30 9 |
| June 21 | 30 7 |
| July 27 | 31 0 |
| Sept. 17 | 32 8 |
| Dec. 14 | 31 4½ |

5. J. P. Brockley, ¾ mile N. of Howard Summit.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 3 | 83 7 |
| Nov. 4 | 83 9 |
| Dec. 6 | 83 9 |
| 1905. | |
| Jan. 3 | 83 8 |
| Feb. 6 | 83 8 |
| Mar. 14 | 83 5 |
| Apr. 10 | 83 5 |
| May 3 | 83 4 |
| June 9 | 83 8 |
| July 10 | 84 2 |
| Aug. 8 | 84 7½ |
| Sept. 11 | 84 11 |
| Nov. 3 | 85 1 |
| Dec. 14 | 84 9 |
| 1906. | |
| Jan. 22 | 84 4½ |
| Mar. 19 | 84 6½ |
| May 2 | 83 4 |
| June 21 | 85 2½ |
| July 27 | 85 1 |
| Sept. 17 | 85 9 |
| Dec. 14 | 87 2 |

6. F. H. Carrell, 1¼ miles SW. of Gardena.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Dec. 6 | 27 1 |
| 1905. | |
| Jan. 3 | 26 5 |
| Feb. 6 | 25 7½ |
| Mar. 14 | 25 7 |
| Apr. 12 | 25 8 |
| May 3 | 25 8 |
| June 9 | 26 4 |
| July 10 | 29 9 |
| Aug. 8 | 29 10 |
| Sept. 11 | 29 7 |
| Nov. 3 | 28 0 |
| Dec. 14 | 26 6½ |
| 1906. | |
| Jan. 22 | 26 2 |
| Mar. 19 | 25 1 |
| May 2 | 26 8 |
| June 21 | 28 10 |
| July 27 | 30 1 |
| Sept. 17 | 29 8 |
| Dec. 14 | 26 11 |

7. A. B. Caldwell, ¼ mile S. of Moneta.

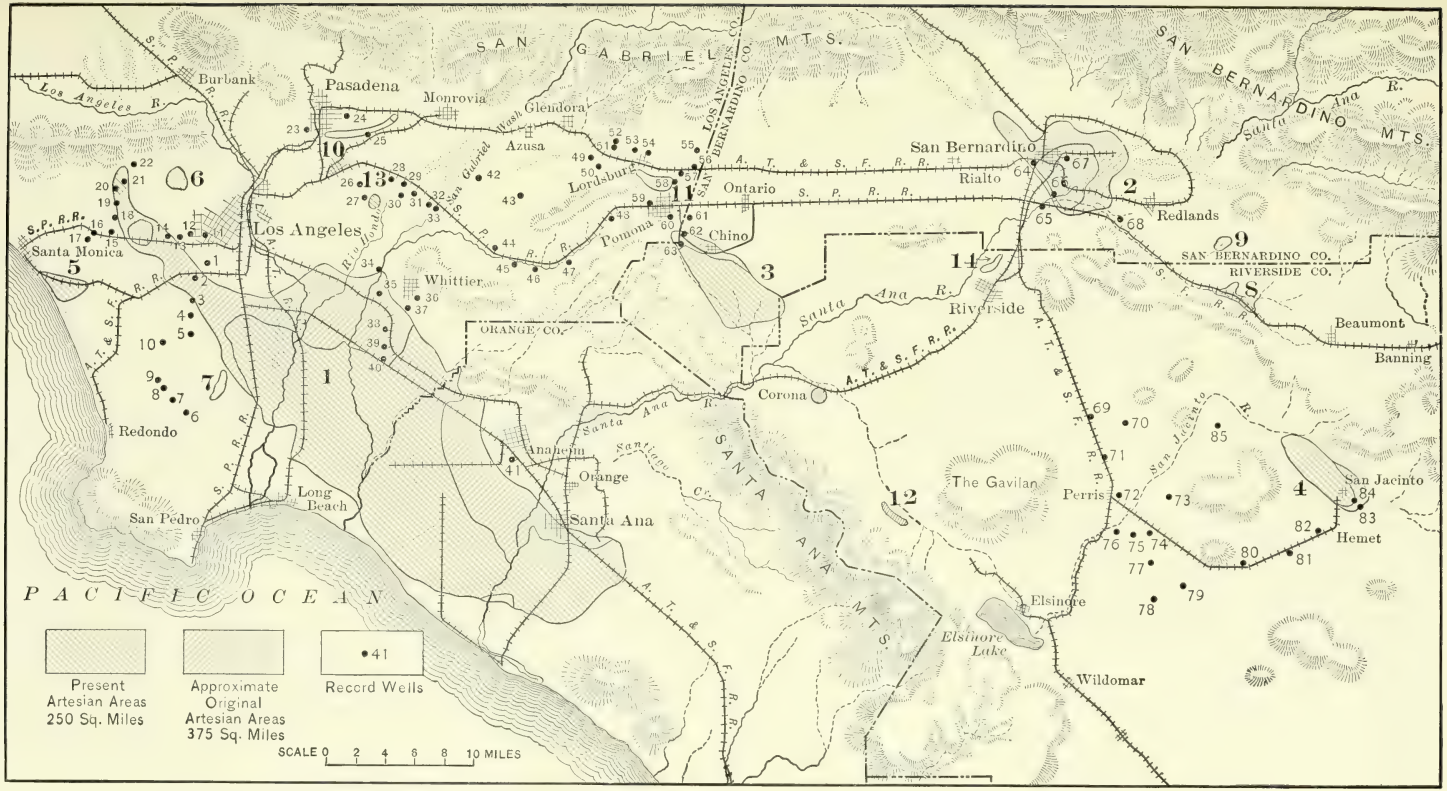
| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Sept. 1 | 41 11 |
| Oct. 3 | 32 6 |
| Nov. 4 | 38 11 |
| Dec. 6 | 25 7 |
| 1905. | |
| Jan. 3 | 26 5 |
| Feb. 6 | 41 9 |
| Mar. 14 | 23 10 |
| Apr. 10 | 48 2 |
| May 3 | 42 10 |
| June 9 | 32 2 |
| July 10 | 33 0 |
| Aug. 8 | 32 6 |
| Sept. 11 | 33 0 |
| Nov. 3 | 28 4 |
| Dec. 14 | 24 11 |
| 1906. | |
| Jan. 22 | 24 6 |
| Mar. 19 | 23 8 |
| May 2 | 27 11 |
| June 21 | 32 3 |
| July 27 | 32 6½ |
| Sept. 17 | 30 8½ |
| Dec. 14 | 25 0 |

8. H. J. Harris, ½ mile N. of Moneta.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Sept. 1 | 39 3 |
| Oct. 3 | 37 9 |
| Nov. 4 | 35 0 |
| Dec. 6 | 32 4 |
| 1905. | |
| Jan. 3 | 26 5½ |
| Feb. 6 | 25 11 |
| Mar. 14 | 25 8½ |
| Apr. 10 | 32 8 |
| May 3 | 28 3 |
| June 9 | 35 2 |
| July 10 | 33 9 |
| Aug. 8 | 33 7 |
| Sept. 11 | 34 5 |
| Dec. 14 | 26 7 |
| 1906. | |
| Jan. 22 | 26 0 |
| Mar. 19 | 23 7 |
| May 2 | 28 0 |
| June 21 | 28 6 |
| July 27 | 34 0 |
| Sept. 17 | 34 0 |
| Dec. 14 | 26 2 |

9. Stanley Bates, ¾ mile NW. of Moneta.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Dec. 6 | 36 4 |
| 1905. | |
| Jan. 3 | 36 1 |
| Feb. 6 | 35 5 |
| Mar. 14 | 35 3 |
| Apr. 10 | 35 1 |
| May 3 | 35 3 |
| June 9 | 36 0 |
| July 10 | 36 8½ |
| Aug. 8 | 37 1½ |
| Sept. 11 | 37 4 |
| Nov. 3 | 37 0 |
| Dec. 14 | 36 3½ |
| 1906. | |
| Jan. 22 | 36 0 |
| Mar. 19 | 34 0 |
| May 2 | 33 4½ |
| June 21 | 32 3 |
| July 27 | 39 2 |
| Sept. 17 | 39 2 |
| Dec. 14 | 36 3 |




MAP OF VALLEY OF SOUTHERN CALIFORNIA, SHOWING LOCATION OF WELLS SELECTED TO SHOW GROUND-WATER CONDITIONS.

*Tables showing variations of water level in wells in southern California*—Continued.

10. Post and Lockhart, 2 miles W. of Howard Summit.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Dec. 6 | 35 7½ |
| 1905. | |
| Jan. 3 | 36 9 |
| Feb. 6 | 38 6 |
| Mar. 14 | 27 4 |
| Apr. 10 | 35 8 |
| May 3 | 35 9 |
| July 10 | 38 6 |
| Aug. 8 | 40 3 |
| Sept. 11 | 47 4 |
| Dec. 14 | 39 3 |
| 1906. | |
| Jan. 22 | 36 0 |
| Mar. 19 | 34 3 |
| May 2 | 33 4½ |
| June 21 | 38 2 |
| July 27 | 37 10 |
| Sept. 17 | 37 10½ |
| Dec. 14 | 37 1½ |

11. William Bayley, Chester place, Los Angeles.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Dec. 9 | 69 0 |
| 1905. | |
| Jan. 6 | 69 2½ |
| Feb. 10 | 69 5 |
| Mar. 18 | 69 9 |
| Apr. 10 | 69 8 |
| May 6 | 69 8 |
| June 10 | 69 8 |
| July 11 | 69 10 |
| Aug. 9 | 70 0 |
| Sept. 12 | 70 1½ |
| Nov. 4 | 70 4 |
| Dec. 15 | 70 5½ |
| 1906. | |
| Jan. 23 | 70 6½ |
| Mar. 20 | 70 4 |
| May 3 | 70 6½ |
| June 23 | 70 7 |
| July 28 | 70 7 |
| Sept. 18 | 70 9 |
| Dec. 15 | 71 0 |

12. Tony Bright, W. Jefferson street, Los Angeles.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Dec. 9 | 48 6 |
| 1905. | |
| Jan. 6 | 48 8 |
| Feb. 10 | 48 10 |
| Mar. 18 | 48 8½ |
| Apr. 10 | 48 4 |
| May 6 | 48 1 |
| June 10 | 48 6 |
| July 11 | 48 10½ |
| Aug. 9 | 49 1½ |
| Sept. 12 | 49 4½ |
| Nov. 4 | 49 6 |
| Dec. 15 | 49 8½ |
| 1906. | |
| Jan. 23 | 49 8 |
| Mar. 20 | 49 4 |
| May 3 | 49 4 |
| June 22 | 49 6½ |
| July 28 | 49 10 |
| Sept. 18 | 50 1 |
| Dec. 15 | 50 0 |

13. Mrs. Showers, W. Jefferson st., Los Angeles.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 3 | 33 8 |
| Nov. 7 | 33 9 |
| Dec. 9 | 33 6 |
| 1905. | |
| Jan 6 | 33 6 |
| Feb. 10 | 33 0 |
| Mar. 18 | 32 2½ |
| Apr. 12 | 32 1 |
| May 6 | 32 9 |
| June 10 | 33 0 |
| July 11 | 33 9 |
| Aug. 9 | 34 4 |
| Sept. 12 | 34 7 |
| Nov. 4 | 34 9 |
| Dec. 15 | 34 3 |
| 1906. | |
| Jan. 23 | 34 1 |
| Mar. 20 | 33 3 |
| May 3 | 33 6 |
| June 22 | 33 11 |
| May 3 | 33 6 |
| June 22 | 33 11 |
| July 28 | 34 7½ |
| Sept. 18 | 35 3 |
| Dec. 15 | 34 9 |

14. Artesian Land and Water Co., ¾ mile N. of Cienega station.

| Date of measurement. | Depth to water. |
|---|---|
| 1905. | *Ft. in.* |
| Feb. 10 | 6 11 |
| Mar. 17 | 5 8½ |
| Apr. 13 | 5 10 |
| May 6 | 6 1 |
| June 10 | 7 2 |
| July 11 | 7 9 |
| Aug. 9 | 8 4 |
| Sept. 12 | 8 9 |
| Dec. 15 | 8 1 |
| 1906. | |
| Jan. 23 | 7 1 |
| Mar. 20 | 7 10 |
| May 3 | 7 3½ |
| June 22 | 7 10 |
| July 28 | 9 0 |
| Sept. 18 | 9 6 |
| Dec. 15 | 8 5½ |

15. Los Angeles County, Ivy station.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Dec. 9 | 13 11 |
| 1905. | |
| Jan. 6 | 13 0 |
| Mar. 18 | 12 1 |
| Apr. 13 | 12 0 |
| June 10 | 12 3 |
| July 11 | 12 7 |
| Aug. 9 | 13 0 |
| Sept. 12 | 13 4½ |
| Nov. 4 | 13 3 |
| Dec. 15 | 13 3½ |
| 1906. | |
| Jan. 23 | 13 1 |
| Mar. 20 | 12 5 |
| May 3 | 12 2 |
| June 22 | 9 8½ |
| July 28 | 12 10 |
| Sept. 18 | 13 3 |
| Dec. 15 | 13 3½ |

*Tables showing variations of water level in wells in southern California*—Continued.

16. M. P. Kane, Palms.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 1 | 50 8 |
| Oct. 12 | 49 6 |
| Nov. 7 | 49 6 |
| Dec. 9 | 50 2 |
| 1905. | |
| Jan. 6 | 49 9 |
| Mar. 18 | 49 4 |
| Apr. 13 | 49 4 |
| July 11 | 49 8 |
| Aug. 9 | 49 11 |
| Sept. 12 | 49 7 |
| Dec. 15 | 49 5½ |
| 1906. | |
| Jan. 23 | 49 6 |
| Mar. 20 | 49 2½ |
| June 22 | 49 5 |
| July 28 | 49 5½ |
| Sept. 18 | 49 10 |
| Dec. 15 | 49 11 |

17. F. P. Bojorquez, Palms.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Oct. 13 | 42 2½ |
| Nov. 7 | 42 4 |
| Dec. 9 | 45 5 |
| 1905. | |
| Jan. 6 | 42 9½ |
| Mar. 18 | 43 3 |
| Apr. 13 | 43 4½ |
| May 6 | 43 6 |
| June 10 | 43 6 |
| July 11 | 43 8 |
| Aug. 9 | 43 11 |
| Sept. 12 | 44 1 |
| Nov. 4 | 43 6 |
| Dec. 15 | 45 7 |
| 1906. | |
| Jan. 23 | 44 5 |
| Mar. 20 | 44 2 |
| May 3 | 44 7 |
| June 22 | 46 7 |
| July 28 | 44 6½ |
| Sept. 18 | 44 6 |
| Dec. 15 | 44 8 |

18. Jose Sesma, 1 mile N. of Ivy station.

| Date of Measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 2 | 43 3 |
| 1905. | |
| Jan. 6 | 43 4½ |
| Feb. 10 | 43 9 |
| Mar. 18 | 43 6 |
| Apr. 13 | 43 5 |
| June 10 | 43 6 |
| July 11 | 43 7 |
| Aug. 9 | 43 8 |
| Sept. 12 | 43 10 |
| Nov. 4 | 42 9 |
| Dec. 15 | 43 11½ |
| 1906. | |
| May 3 | 44 1½ |
| June 22 | 45 2½ |
| July 28 | 44 4 |
| Dec. 15 | 44 7 |

19. J. H. Whitworth, 2 miles S. of Sherman.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 9 | 10 9 |
| 1905. | |
| Jan. 6 | 10 6 |
| Feb. 10 | 9 9 |
| Mar. 18 | 8 2 |
| Apr. 13 | 8 0 |
| May 6 | 8 4 |
| June 10 | 9 2 |
| July 11 | 9 0 |
| Aug. 9 | 8 8 |
| Nov. 4 | 9 7½ |
| Dec. 15 | 9 4 |
| 1906. | |
| Jan. 23 | 8 9 |
| Mar. 20 | 8 8 |
| May 3 | 7 8½ |
| June 22 | 9 5½ |
| July 28 | 9 8½ |
| Sept. 18 | 10 1 |
| Dec. 15 | 8 7 |

20. Hammel and Decker, 1 mile S. of Sherman.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 9 | 13 6 |
| 1905. | |
| Jan. 6 | 13 6 |
| Feb. 10 | 12 11½ |
| Mar. 18 | 11 9 |
| Apr. 13 | 11 6 |
| May 6 | 11 7 |
| June 10 | 11 10 |
| July 11 | 12 1 |
| Aug. 9 | 12 4 |
| Sept. 12 | 12 10 |
| Nov. 4 | 13 0 |
| Dec. 15 | 12 10 |
| 1906. | |
| Jan 23 | 12 4½ |
| Mar. 20 | 12 1½ |
| May 3 | 11 9½ |
| June 22 | 12 1 |
| July 28 | 12 7½ |
| Sept. 18 | 12 10½ |
| Dec. 15 | 12 6 |

21. William Niles, ¾ mile S. of Sherman.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Oct. 14 | 9 0 |
| Nov. 7 | 9 2 |
| Dec. 9 | 9 3 |
| 1905. | |
| Jan. 6 | 7 6 |
| Feb. 10 | 6 2 |
| Mar. 18 | 4 3 |
| Apr. 13 | 6 6 |
| May 6 | 6 8 |
| June 10 | 7 0 |
| July 11 | 8 2 |
| Aug. 9 | 8 10 |
| Sept. 12 | 9 5 |
| Dec. 15 | 7 6 |
| 1906. | |
| Jan. 23 | 7 3 |
| Mar. 20 | 7 4 |
| May 3 | 7 8 |
| June 22 | 8 5 |
| July 28 | 8 2½ |
| Sept. 18 | 9 6½ |
| Dec. 15 | 7 2½ |

*Tables showing variations of water level in wells in southern California*—Continued.

22. Los Angeles County, 1 mile E. of Sherman.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 9 | 84 3½ |
| 1905. | |
| Jan. 6 | 84 5½ |
| Feb. 10 | 84 6 |
| Mar. 18 | 84 6 |
| Apr. 13 | 84 4 |
| May 6 | 84 3 |
| June 10 | 84 6 |
| July 11 | 84 6 |
| Aug. 9 | 84 10 |
| Sept. 12 | 85 2 |
| Nov. 4 | 86 0 |
| Dec. 15 | 86 9 |
| 1906. | |
| Jan. 23 | 84 6 |
| Mar. 20 | 86 3 |
| May 3 | 86 5 |
| June 22 | 86 8½ |
| July 28 | 87 5½ |
| Sept. 18 | 87 8½ |
| Dec. 15 | 88 1 |

23. Mr. Hurlbut, Pasadena.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 2 | 73 3 |
| Oct. 5 | 73 10 |
| Nov. 8 | 73 11 |
| Dec. 10 | 74 6 |
| 1905. | |
| Jan. 4 | 74 6 |
| Feb. 9 | 74 4 |
| Apr. 12 | 73 8 |
| May 10 | 73 5 |
| June 13 | 73 5 |
| July 12 | 74 0 |
| Aug. 10 | 74 5 |
| Sept. 13 | 75 0 |
| Nov. 7 | 75 0 |
| Dec. 18 | 75 9 |
| 1906. | |
| Mar. 22 | 74 6 |
| May 5 | 74 9 |
| June 25 | 74 6 |
| July 31 | 75 3½ |
| Sept. 20 | 76 1½ |
| Dec. 17 | 77 1 |

24. L. V. Harkness, 1½ mile SE. of Pasadena.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 2 | 122 4 |
| Oct. 5 | 122 2½ |
| Nov. 8 | 122 7 |
| Dec. 10 | 122 6½ |
| 1905. | |
| Feb. 9 | 122 2 |
| Mar. 17 | 122 2 |
| Apr. 12 | 122 2 |
| May 10 | 122 1 |
| June 13 | 122 4 |
| July 12 | 123 3 |
| Aug. 10 | 123 5 |
| Sept. 13 | 124 0 |
| Nov. 7 | 124 1 |
| Dec. 18 | 123 7 |
| 1906. | |
| Jan. 24 | 123 3½ |
| Mar. 22 | 123 2½ |
| May 5 | 122 11 |
| June 25 | 122 8 |
| July 31 | 123 6½ |
| Sept. 20 | 123 10 |
| Dec. 17 | 123 1½ |

25. Titus ranch, Sunny Slope station.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 10 | 13 6 |
| 1905. | |
| Jan. 4 | 10 4½ |
| Feb. 9 | 8 7 |
| Mar. 17 | 8 6 |
| Apr. 12 | 7 8 |
| May 10 | 8 1 |
| June 13 | 11 6 |
| July 12 | 16 1 |
| Aug. 10 | 19 2 |
| Sept. 13 | 16 2 |
| Nov. 7 | 12 10 |
| Dec. 18 | 10 7 |
| 1906. | |
| Jan. 24 | 10 9 |
| Mar. 22 | 10 0 |
| June 25 | 8 6 |
| May 5 | 8 4 |
| May 5 | 8 4 |
| July 31 | 18 3 |
| Sept. 20 | 16 9½ |
| Dec. 17 | 14 2½ |

26. John McClain estate, 1 mile S. of San Gabriel.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 10 | 72 11 |
| 1905. | |
| Jan. 4 | 72 10 |
| Feb. 9 | 73 0 |
| Mar. 17 | 72 10 |
| Apr. 12 | 72 7 |
| June 13 | 73 4 |
| July 12 | 73 3 |
| Aug. 10 | 74 1 |
| Dec. 18 | 73 0 |
| 1906. | |
| Mar. 22 | 72 8½ |
| May 5 | 72 7½ |
| June 25 | 72 8 |
| July 31 | 72 3½ |
| Sept. 20 | 72 1 |
| Dec. 17 | 71 4 |

27. F. E. Wilson, 2 miles S. of San Gabriel.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 10 | 23 5½ |
| 1905. | |
| Jan. 4 | 23 6 |
| Feb. 7 | 23 3 |
| Mar. 17 | 22 8½ |
| Apr. 12 | 21 0 |
| July 12 | 21 4 |
| Aug. 10 | 22 6 |
| Sept. 13 | 22 3 |
| Nov. 17 | 22 8 |
| Dec. 18 | 22 11 |
| 1906. | |
| Jan. 24 | 22 3 |
| Mar. 22 | 23 0 |
| May 5 | 22 8 |
| June 25 | 21 8 |
| July 31 | 21 4 |
| Dec. 17 | 21 11 |

*Tables showing variations of water level in wells in southern California*—Continued.

28. G. B. Renfro, ¾ mile SW. of Savannah.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 9 | 19 6 |
| 1905. | |
| Jan. 4 | 20 1½ |
| Feb. 9 | 20 0 |
| Mar. 17 | 19 3 |
| Apr. 12 | 18 4 |
| May 10 | 17 8 |
| June 13 | 18 7 |
| July 12 | 18 11 |
| Aug. 10 | 19 2 |
| Sept. 13 | 20 0 |
| Nov. 7 | 20 3 |
| 1906. | |
| Jan. 24 | 19 10 |
| Mar. 22 | 18 11 |
| May 5 | 18 1 |
| June 25 | 18 4 |
| July 31 | 18 8 |
| Dec. 17 | 18 8 |

29. J. A. Law, ½ mile W. of El Monte.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 10 | 16 2 |
| 1905. | |
| Jan. 4 | 16 1½ |
| Feb. 9 | 16 3 |
| Mar. 17 | 13 8 |
| Apr. 12 | 13 2 |
| July 12 | 13 1 |
| Aug. 10 | 13 5½ |
| Sept. 13 | 14 4 |
| Nov. 7 | 14 1 |
| Dec. 18 | 13 9 |
| 1906. | |
| Jan. 24 | 13 8½ |
| Mar. 22 | 12 6 |
| May 5 | 11 8 |
| June 25 | 11 5 |
| July 31 | 11 10½ |
| Sept. 20 | 12 2½ |
| Dec. 17 | 11 9 |

30. M. Ritter, El Monte.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Nov. 8 | 22 5 |
| Dec. 10 | 22 6½ |
| 1905. | |
| Jan. 4 | 22 6 |
| Feb. 9 | 21 9 |
| Mar. 17 | 20 1 |
| Apr. 12 | 18 1 |
| May 10 | 16 8 |
| June 13 | 16 11 |
| July 12 | 17 5 |
| Aug. 10 | 16 8 |
| Sept. 13 | 17 5 |
| Nov. 7 | 18 2 |
| Dec. 18 | 18 0 |
| 1906. | |
| Jan. 24 | 18 9½ |
| Mar. 22 | 17 3 |
| May 5 | 14 4 |
| June 25 | 12 9½ |
| July 31 | 12 11½ |
| Sept. 20 | 14 1 |
| Dec. 17 | 14 7½ |

31. Mrs. McClure, ¾ mile S. of El Monte.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1905. | |
| Jan. 4 | 16 6 |
| Feb. 9 | 15 10 |
| Mar. 17 | 14 2 |
| July 12 | 12 5 |
| Aug. 10 | 13 9 |
| Sept. 13 | 14 8 |
| Nov. 7 | 13 6 |
| Dec. 18 | 13 6 |
| 1906. | |
| Jan. 24 | 13 1 |
| Mar. 22 | 12 10 |
| May 5 | 10 6 |
| June 25 | 10 0 |
| July 31 | 10 4½ |
| Sept. 20 | 12 ½ |
| Dec. 17 | 10 7 |

32. T. D. Andrews, 1½ mile SE. of El Monte.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 10 | 21 5½ |
| 1905. | |
| Jan. 4 | 21 5 |
| Feb. 9 | 20 8 |
| Mar. 17 | 17 10 |
| Apr. 12 | 15 10 |
| May 10 | 14 8 |
| June 12 | 13 8 |
| July 12 | 13 9 |
| Aug. 10 | 15 9 |
| Sept. 13 | 16 10 |
| Nov. 7 | 17 3 |
| Dec. 17 | 17 0 |
| 1906. | |
| Jan. 24 | 17 4 |
| Mar. 22 | 15 4 |
| May 5 | 12 8 |
| June 25 | 11 9 |
| July 31 | 12 2 |
| Sept. 20 | 13 5½ |
| Dec. 17 | 13 8 |

33. Jackson Frees, 2 miles SE. El Monte.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1905. | |
| Feb. 9 | 27 5 |
| Mar. 17 | 23 4½ |
| Apr. 12 | 20 2 |
| May 10 | 20 8 |
| June 13 | 18 6 |
| July 12 | 19 9 |
| Aug. 10 | 21 0 |
| Sept. 13 | 22 4 |
| Nov. 7 | 23 3 |
| Dec. 18 | 22 9 |
| 1906. | |
| Jan. 24 | 19 10 |
| Mar. 22 | 22 11 |
| May 5 | 18 1½ |
| June 25 | 18 1½ |
| July 31 | 17 3 |
| Sept. 20 | 18 9 |
| Dec. 17 | 19 10 |

*Tables showing variations of water level in wells in southern California*—Continued.

34. E. Gurado 3 miles W. of Whittier.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Oct. 4 | 14 2 |
| Nov. 8 | 13 4 |
| Dec. 7 | 12 1 |
| 1905. | |
| Jan. 5 | 11 6 |
| Feb. 7 | 11 2 |
| Mar. 15 | 10 3 |
| Apr. 11 | 10 5½ |
| May 5 | 10 7½ |
| June 12 | 11 8 |
| July 14 | 12 ½ |
| Aug. 11 | 12 6 |
| Sept. 14 | 13 0 |
| Nov. 6 | 11 10 |
| Dec. 16 | 11 3 |
| 1906. | |
| Jan. 25 | 11 11 |
| Mar. 10 | 10 3½ |
| May 4 | 9 6½ |
| June 23 | 11 3 |
| July 30 | 9 8½ |
| Sept. 19 | 10 0 |
| Dec. 18 | 9 9½ |

35. Mrs. Mary Pheland, 2 miles SW. of Whittier.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Nov. 9 | 15 3 |
| 1905. | |
| Jan. 5 | 14 11½ |
| Feb. 7 | 14 2½ |
| Mar. 15 | 13 4 |
| Apr. 10 | 13 2 |
| May 5 | 13 4 |
| June 12 | 13 8½ |
| July 14 | 14 5 |
| Aug. 11 | 15 0 |
| Sept. 14 | 15 8 |
| Nov. 6 | 14 5 |
| Dec. 16 | 13 10 |
| 1906. | |
| June 23 | 12 3 |
| July 30 | 14 9 |
| Sept. 19 | 17 10 |
| Dec. 18 | 12 6½ |

36. H. C. Baldwin, ½ mile SE. of Whittier.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 8 | 129 2 |
| Oct. 4 | 128 4½ |
| Nov. 8 | 128 5 |
| Dec. 7 | 128 7½ |
| 1905. | |
| Jan. 5 | 128 6 |
| Feb. 7 | 128 7 |
| March 15 | 128 8 |
| Apr. 11 | 128 4 |
| May 5 | 128 3 |
| June 12 | 128 4½ |
| July 14 | 128 8 |
| Aug. 11 | 128 10 |
| Sept. 14 | 128 11 |
| Nov. 6 | 129 0 |
| Dec. 16 | 128 10 |
| 1906. | |
| Jan. 20 | 128 8 |
| Mar. 10 | 128 8 |
| May 4 | 127 5½ |
| June 23 | 128 6 |
| July 30 | 128 6 |
| Sept. 19 | 128 6½ |
| Dec. 18 | 128 6 |

37. C. A. Landreth, 1 mile S. of Whittier.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 6 | 33 5½ |
| Oct. 4 | 33 7½ |
| Nov. 9 | 33 5 |
| Dec. 7 | 33 5½ |
| 1905. | |
| Jan. 5 | 33 8 |
| Feb. 7 | 33 3 |
| Mar. 15 | 32 6 |
| Apr. 11 | 31 10 |
| May 5 | 31 8 |
| June 12 | 31 7 |
| July 14 | 32 4 |
| Aug. 11 | 33 2 |
| Sept. 14 | 33 4 |
| Nov. 6 | 33 1 |
| Dec. 16 | 32 10 |
| 1906. | |
| Jan. 25 | 32 8 |
| Mar. 10 | 31 8 |
| May 4 | 31 6½ |
| June 23 | 31 5½ |
| July 30 | 33 4 |
| Sept. 19 | 32 6 |
| Dec. 18 | 32 ½ |

38. J. W. Sharp, Santa Fe Springs.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 6 | 27 3½ |
| Oct. 4 | 26 9½ |
| Nov. 9 | 27 2 |
| Dec. 7 | 27 7 |
| 1905. | |
| Jan. 5 | 27 0 |
| Feb. 7 | 26 2 |
| Mar. 15 | 25 7 |
| Apr. 11 | 25 0 |
| May 5 | 25 1½ |
| June 12 | 26 0 |
| July 14 | 26 8 |
| Aug. 11 | 27 2 |
| Sept. 14 | 27 4 |
| Nov. 6 | 27 3 |
| Dec. 16 | 26 1 |
| 1906. | |
| Jan. 25 | 25 4 |
| Mar. 10 | 24 6 |
| May 4 | 24 5½ |
| June 23 | 24 9 |
| July 30 | 25 8½ |
| Sept. 19 | 26 9 |
| Dec. 18 | 25 1 |

39. John H. Borden, 1½ miles N. of Norwalk.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Nov. 9 | 7 10 |
| Dec. 7 | 8 5 |
| 1905. | |
| Jan. 5 | 7 11 |
| Feb. 7 | 6 10 |
| Mar. 15 | 5 10½ |
| Apr. 11 | 5 4 |
| May 5 | 5 1 |
| June 12 | 6 6 |
| July 14 | 7 2 |
| Aug. 11 | 8 0 |
| Sept. 14 | 8 8 |
| Nov. 6 | 8 7 |
| Dec. 16 | 7 1 |
| 1906. | |
| Jan. 25 | 6 7 |
| Mar. 10 | 6 8 |
| May 4 | 4 10½ |
| June 23 | 5 6½ |
| July 30 | 7 3½ |
| Sept. 19 | 6 9½ |
| Dec. 18 | 5 10 |

*Tables showing variations of water level in wells in southern California*—Continued.

40. Norwalk Builders' Association, Norwalk.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 6 | 19 5 |
| Oct. 4 | 15 8 |
| Nov. 9 | 16 4 |
| Dec. 7 | 17 4 |
| 1905. | |
| Jan. 5 | 15 3½ |
| Feb. 7 | 14 1½ |
| Mar. 15 | 13 4½ |
| May 5 | 13 7 |
| June 12 | 14 6 |
| July 14 | 15 10 |
| Aug. 11 | 16 11 |
| Sept. 14 | 17 9 |
| Nov. 6 | 15 4 |
| Dec. 16 | 14 7 |
| 1906. | |
| Jan. 25 | 13 8 |
| Mar. 10 | 16 11 |
| May 4 | 16 3 |
| June 23 | 15 6½ |
| July 30 | 15 4½ |
| Dec. 18 | 15 0 |

41. J. B. Neff, 1½ miles S. of Anaheim.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Aug. 31 | 50 10 |
| Oct. 1 | 50 8 |
| Oct. 31 | 50 8 |
| Dec. 1 | 50 9 |
| 1905. | |
| Jan. 1 | 51 0 |
| Feb. 1 | 50 11 |
| Mar. 1 | 50 7 |
| Mar. 31 | 49 10 |
| May 18 | 49 7 |
| July 1 | 51 4 |
| July 31 | 51 7 |
| Aug. 31 | 52 7 |
| Sept. 30 | 52 4 |
| Nov. 1 | 51 10 |
| Dec. 1 | 51 5 |
| 1906. | |
| Jan. 6 | 51 4 |
| Mar. 3 | 51 2 |
| Mar. 31 | 50 10 |
| Apr. 30 | 49 5 |
| May 19 | 49 2 |
| July 1 | 49 7 |
| July 30 | 50 6 |
| Sept. 2 | 51 1 |
| Sept. 27 | 50 9 |
| Nov. 1 | 50 2 |
| Nov. 30 | 49 5 |

42. Vineland district school, Vineland.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 14 | 104 1 |
| 1905. | |
| Jan. 12 | 104 6 |
| Feb. 21 | 102 10 |
| Mar. 10 | 98 9 |
| Apr. 15 | 93 11 |
| May 17 | 90 8 |
| June 22 | 90 11 |
| July 21 | 91 4 |
| Aug. 16 | 92 2 |
| Sept. 20 | 93 9 |
| Nov. 12 | 95 9 |
| Dec. 21 | 96 7 |
| 1906. | |
| Jan. 27 | 97 0 |
| Mar. 15 | 95 3 |
| May 8 | 83 4 |
| June 7 | 81 ½ |
| Aug. 1 | 82 11 |
| Sept. 25 | 85 11 |
| Dec. 11 | 88 10 |

43. G. F. Chamberlain, 2 miles SW. of Covina.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Oct. 8 | 119 0 |
| Nov. 17 | 119 6 |
| Dec. 14 | 120 9 |
| 1905. | |
| Jan. 12 | 120 11 |
| Feb. 20 | 120 9 |
| Mar. 11 | 120 1 |
| Apr. 15 | 118 1 |
| May 17 | 117 9 |
| July 21 | 112 6 |
| Aug. 16 | 111 6 |
| Sept. 21 | 111 6 |
| Nov. 12 | 112 6 |
| Dec. 21 | 112 11 |
| 1906. | |
| Mar. 15 | 113 7 |
| May 9 | 109 6 |
| June 27 | 105 3½ |
| Sept. 25 | 104 4½ |
| Dec. 11 | 108 1 |

44. H. Heinze, Puente.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Oct. 8 | 30 0 |
| Nov. 17 | 29 10 |
| Dec. 14 | 30 0 |
| 1905. | |
| Feb. 21 | 29 2 |
| Mar. 11 | 28 4 |
| Apr. 15 | 25 7 |
| June 22 | 28 6 |
| July 21 | 27 2 |
| Aug. 16 | 27 11 |
| Sept. 20 | 28 3 |
| Dec. 21 | 28 4½ |
| 1906. | |
| Mar. 15 | 23 9 |
| May 9 | 25 6 |
| June 27 | 23 7½ |
| Sept. 25 | 26 4½ |

45. William Rowland, ¼ mile S. of Rowland.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Oct. 8 | 27 0 |
| Nov. 17 | 26 10 |
| Dec. 14 | 25 7 |
| 1905. | |
| Jan. 12 | 24 9 |
| Feb. 21 | 23 1 |
| Apr. 15 | 22 8 |
| June 22 | 23 9 |
| July 21 | 24 8 |
| Aug. 16 | 24 10 |
| Sept. 20 | 26 0 |
| Nov. 12 | 24 5 |
| Dec. 21 | 23 5 |
| 1906. | |
| Jan. 27 | 23 5 |
| May 9 | 22 11½ |
| June 27 | 27 7 |
| Aug. 2 | 25 4 |
| Sept. 25 | 27 0 |
| Dec. 11 | 23 8 |

*Tables showing variations of water in wells in southern California*—Continued.

46. B. Yorba, 1½ miles E. of Rowland.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 8 | 35 6 |
| Nov. 17 | 35 10½ |
| Dec. 14 | 33 5 |
| 1905. | |
| Jan. 12 | 30 8 |
| Feb. 20 | 29 9 |
| Mar. 11 | 30 10 |
| Apr. 15 | 31 0 |
| June 22 | 32 11 |
| July 21 | 33 2 |
| May 20 | 33 11 |
| Nov. 12 | 33 0 |
| Dec. 21 | 31 5 |
| 1906. | |
| Jan. 27 | 31 7 |
| Mar. 15 | 28 2½ |
| May 9 | 31 6 |
| June 27 | 30 8 |
| Aug. 2 | 31 11 |
| Sept. 25 | 32 11 |

47. F. Bowers, Lemon.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 8 | 27 10 |
| Nov. 16 | 25 4 |
| Dec. 14 | 25 5½ |
| 1905. | |
| Jan. 12 | 24 4 |
| Feb. 20 | 23 10 |
| Mar. 11 | 23 6 |
| Apr. 15 | 20 5½ |
| June 22 | 23 5 |
| July 21 | 24 0 |
| Aug. 16 | 25 10 |
| Sept. 20 | 25 ½ |
| Nov. 12 | 23 4 |
| Dec. 21 | 22 0 |
| 1906. | |
| Jan. 27 | 21 6 |
| Mar. 15 | 21 4 |
| May 9 | 21 10 |
| June 27 | 24 8½ |
| Aug. 2 | 25 8 |
| Sept. 25 | 25 4½ |

48. S. E. Hicks, ¼ mile W. of Spadra.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 8 | 33 8 |
| Nov. 17 | 32 9 |
| Dec. 14 | 32 9 |
| 1905. | |
| Jan. 12 | 32 0 |
| Feb. 21 | 31 8½ |
| Mar. 11 | 31 5½ |
| June 22 | 32 7 |
| July 21 | 34 2 |
| Aug. 16 | 35 2 |
| Sept. 20 | 36 6 |
| Nov. 12 | 36 2 |
| Dec. 21 | 35 7 |
| 1906. | |
| Mar. 15 | 35 5 |
| May 9 | 34 8 |
| June 27 | 34 8 |
| Aug. 2 | 38 7½ |
| Sept. 25 | 40 2 |
| Dec. 11 | 39 3 |

49. Sidney Deacon, 2 miles W. of San Dimas.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 7 | 124 3 |
| Nov. 16 | 124 0 |
| Dec. 13 | 124 0 |
| 1905. | |
| Jan. 11 | 123 6 |
| Feb. 20 | 123 5 |
| Mar. 10 | 127 0 |
| Apr. 14 | 125 0 |
| May 17 | 124 8 |
| June 22 | 125 1½ |
| July 21 | 125 5 |
| Aug. 16 | 125 5 |
| Sept. 21 | 125 7 |
| Nov. 11 | 126 0 |
| 1906. | |
| Jan. 27 | 124 6 |
| Mar. 15 | 124 3 |
| May 8 | 125 2 |
| June 27 | 124 6 |

50. Wm. Ferry, 1¼ miles SW. of San Dimas.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 7 | 199 8 |
| Nov. 16 | 199 10 |
| Dec. 13 | 199 10½ |
| 1905. | |
| Jan. 11 | 199 9½ |
| Feb. 21 | 199 8 |
| Mar. 10 | 199 8½ |
| Apr. 14 | 200 4 |
| June 22 | 200 4½ |
| July 23 | 200 6 |
| Aug. 16 | 200 7 |
| Sept. 21 | 200 7 |
| Nov. 11 | 201 0 |
| Dec. 20 | 201 0 |
| 1906. | |
| Jan. 27 | 201 3 |
| Mar. 15 | 201 3 |
| May 8 | 201 2 |
| June 26 | 201 5½ |
| Aug. 2 | 201 9 |
| Sept. 24 | 201 7½ |

51. Azusa Irrigating Co., San Dimas Wash.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 7 | 97 2 |
| Nov. 16 | 97 8 |
| Dec. 13 | 98 11 |
| 1905. | |
| Jan. 11 | 99 1 |
| Feb. 20 | 98 4 |
| Mar. 11 | 97 4 |
| Apr. 14 | 95 6 |
| May 17 | 94 3 |
| June 22 | 94 1 |
| July 20 | 95 4 |
| Aug. 16 | 96 4 |
| Sept. 21 | 97 4 |
| Nov. 11 | 98 6 |
| Dec. 20 | 99 0 |
| 1906. | |
| Jan. 27 | 97 10 |
| Mar. 15 | 97 2½ |
| May 8 | 93 2 |
| June 26 | 91 1½ |
| Aug. 1 | 92 4 |
| Sept. 24 | 98 7½ |
| Dec. 10 | 100 11 |

*Tables showing variations of water in wells in southern California*—Continued.

52. Emil Firth, San Dimas Wash.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft.* *in.* |
| 1904. | |
| Sept. 7 | 110 6½ |
| Oct. 7 | 111 7 |
| Nov. 16 | 113 2 |
| Dec. 13 | 113 11 |
| 1905. | |
| Jan. 11 | 114 8½ |
| Feb. 20 | 113 11 |
| Mar. 11 | 113 7 |
| Apr. 14 | 106 10 |
| May 17 | 104 9 |
| June 22 | 104 4 |
| July 20 | 105 6 |
| Aug. 16 | 105 10 |
| Sept. 21 | 106 7½ |
| Nov. 11 | 108 1½ |
| Dec. 20 | 108 1 |
| 1906. | |
| Jan. 27 | 107 6½ |
| Mar. 15 | 108 2 |
| May 8 | 87 10 |
| June 26 | 92 11 |
| Sept. 24 | 97 4½ |
| Dec. 10 | 96 11 |

53. Charles Alley, 1 mile NW. of Lordsburg.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft.* *in.* |
| 1904. | |
| Oct. 7 | 145 4 |
| Nov. 16 | 146 10 |
| Dec. 13 | 146 10 |
| 1905. | |
| Jan. 11 | 146 9 |
| Feb. 20 | 147 5½ |
| Mar. 10 | 147 6½ |
| Apr. 14 | 147 7 |
| June 22 | 146 8 |
| July 20 | 150 8 |
| Aug. 16 | 150 ½ |
| Sept. 21 | 150 11 |
| Nov. 11 | 152 7 |
| Dec. 20 | 152 0 |
| 1906. | |
| Jan. 27 | 151 5½ |
| Mar. 15 | 149 2½ |
| May 8 | 149 6 |
| June 26 | 149 ½ |
| Aug. 1 | 153 1½ |
| Sept. 24 | 154 4½ |
| Dec. 10 | 154 7 |

54. Mr. Massey, ¾ mile NE. of Lordsburg.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft.* *in.* |
| 1904. | |
| Oct. 7 | 207 2½ |
| Nov. 16 | 199 1 |
| Dec. 13 | 199 3 |
| 1905. | |
| Jan. 11 | 199 11 |
| Feb. 20 | 199 10½ |
| Mar. 11 | 199 9 |
| Apr. 14 | 200 0 |
| May 17 | 199 11 |
| June 22 | 199 4 |
| July 20 | 200 2 |
| Aug. 16 | 199 9 |
| Sept. 21 | 200 0 |
| Nov. 11 | 202 10 |
| Dec. 20 | 200 11 |
| 1906. | |
| Jan. 27 | 201 1 |
| Mar. 15 | 200 2 |
| May 8 | 198 4½ |
| June 26 | 197 6 |
| Aug. 1 | 196 5½ |
| Sept. 24 | 196 7½ |
| Dec. 10 | 197 3½ |

55. Ontario Water Co., 1 mile N. of Claremont.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft.* *in.* |
| 1904. | |
| Nov. 16 | 62 1 |
| Dec. 13 | 61 10 |
| 1905. | |
| Jan. 11 | 62 2 |
| Feb. 20 | 62 1 |
| Mar. 10 | 61 10½ |
| Apr. 14 | 59 4 |
| May 17 | 59 1½ |
| June 22 | 57 5 |
| July 20 | 57 0 |
| Aug. 16 | 59 7 |
| Sept. 21 | 58 6 |
| Nov. 11 | 58 4½ |
| Dec. 20 | 57 3 |
| 1906. | |
| Jan. 26 | 56 9½ |
| Mar. 14 | 53 2½ |
| May 8 | 54 4 |
| June 26 | 53 3½ |
| Aug. 1 | 54 1 |
| Sept. 24 | 53 3½ |
| Dec. 10 | 56 10 |

56. R. Bieley, Claremont.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft.* *in.* |
| 1904. | |
| Oct. 8 | 97 4 |
| Nov. 16 | 97 6 |
| Dec. 13 | 98 1½ |
| 1905. | |
| Jan. 11 | 97 0 |
| Feb. 20 | 92 5 |
| Mar. 10 | 91 2 |
| Apr. 14 | 89 9 |
| May 17 | 88 10 |
| June 22 | 92 0 |
| July 20 | 97 4 |
| Aug. 16 | 98 7 |
| Sept. 21 | 99 9 |
| Dec. 20 | 93 8 |
| 1906. | |
| Jan. 27 | 97 9½ |
| Mar. 14 | 84 10 |
| May 8 | 82 4 |
| June 26 | 81 2 |
| Aug. 1 | 76 3 |
| Sept. 24 | 65 5 |
| Dec. 10 | 49 9 |

57. San Antonio Water Co., ½ mile SW. of Claremont.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft.* *in.* |
| 1904. | |
| Oct. 6 | 158 5 |
| Nov. 16 | 156 2 |
| Dec. 13 | 155 0 |
| 1905. | |
| Jan. 11 | 153 1½ |
| Feb. 20 | 151 1 |
| Mar. 10 | 150 2 |
| Apr. 14 | 148 7 |
| May 17 | 147 1 |
| June 22 | 148 7 |
| July 20 | 150 10 |
| Aug. 16 | 150 8 |
| Sept. 21 | 152 6½ |
| Nov. 11 | 152 1 |
| Dec. 20 | 149 1 |
| 1906. | |
| Jan. 26 | 149 6 |
| Mar. 14 | 144 3 |
| May 8 | 141 2 |
| Aug. 1 | 146 8 |
| Sept. 24 | 149 8½ |
| Dec. 10 | 149 8 |

*Tables showing variations of water in wells in southern California*—Continued.

58. Dr. A. R. Reed, 1½ miles NE. of Pomona.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 7 | 75 2 |
| Oct. 6 | 75 4¼ |
| Nov. 16 | 74 6 |
| Dec. 13 | 74 3 |
| 1905. | |
| Jan. 11 | 68 10½ |
| Feb. 20 | 66 1 |
| Mar. 10 | 65 11 |
| Apr. 14 | 63 11 |
| May 17 | 62 11 |
| June 22 | 66 8 |
| July 20 | 70 10 |
| Aug. 16 | 71 11 |
| Sept. 21 | 73 5 |
| Nov. 11 | 70 4½ |
| Dec. 20 | 67 0 |
| 1906. | |
| Jan. 26 | 64 9 |
| Mar. 14 | 62 10 |
| May 8 | 62 5 |
| June 26 | 64 5 |
| Aug. 1 | 67 0 |
| Sept. 24 | 67 ½ |
| Dec. 10 | 64 3½ |

59. B. Linastruth, Pomona.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 14 | 90 6½ |
| 1905. | |
| Jan. 12 | 90 9 |
| Feb. 21 | 91 1 |
| Apr. 15 | 91 5 |
| May 17 | 91 6½ |
| June 22 | 92 0 |
| July 21 | 92 10½ |
| Sept. 20 | 93 6 |
| Nov. 12 | 93 4 |
| Dec. 21 | 93 6 |
| 1906. | |
| Mar. 15 | 92 6 |
| June 27 | 93 6 |
| Aug. 2 | 95 6 |
| Sept. 25 | 96 0 |
| Dec. 11 | 95 2 |

60. J. J. White, Pomona.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Oct. 6 | 58 9½ |
| Nov. 16 | 60 3 |
| Dec. 13 | 60 6½ |
| 1905. | |
| Jan. 11 | 60 10 |
| Feb. 20 | 61 1½ |
| Mar. 10 | 61 4½ |
| Apr. 14 | 60 8 |
| May 17 | 60 11 |
| June 22 | 61 1 |
| Aug. 16 | 61 6 |
| Sept. 20 | 61 10 |
| Nov. 11 | 62 4 |
| Dec. 20 | 62 5 |
| 1906. | |
| Jan. 26 | 62 3½ |
| Mar. 14 | 63 1 |
| May 8 | 63 1½ |
| Aug. 1 | 63 5 |
| Sept. 24 | 64 4½ |
| Dec. 10 | 64 11 |

61. Mrs. Tieg, 1½ miles SE. of Pomona.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 8 | 89 0 |
| Oct. 6 | 88 10 |
| Nov. 16 | 88 10½ |
| Dec. 13 | 88 10 |
| 1905. | |
| Jan. 11 | 88 10 |
| Feb. 20 | 89 0 |
| Mar. 10 | 89 0 |
| Apr. 14 | 88 0 |
| June 22 | 88 11 |
| July 20 | 90 1½ |
| Aug. 16 | 90 5 |
| Sept. 20 | 90 8½ |
| Nov. 11 | 90 5 |
| Dec. 20 | 90 6 |
| 1906. | |
| Jan. 26 | 89 6 |
| Mar. 14 | 90 6 |
| May 8 | 89 7 |
| Aug. 1 | 92 2 |
| Sept. 24 | 92 2 |

62. R. Riemers, 2½ miles SE. of Pomona.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 8 | 34 6 |
| Oct. 6 | 36 6½ |
| Nov. 16 | 34 10 |
| Dec. 13 | 34 10 |
| 1905. | |
| Jan. 11 | 34 9½ |
| Feb. 20 | 34 7½ |
| Apr. 14 | 32 10 |
| May 17 | 32 7 |
| June 22 | 33 6 |
| July 20 | 35 4 |
| Aug. 16 | 35 0 |
| Sept. 20 | 35 6 |
| Nov. 11 | 35 8 |
| Dec. 20 | 35 7½ |
| 1906. | |
| Jan. 26 | 36 8½ |
| Mar. 14 | 35 8 |
| May 8 | 33 2½ |
| June 26 | 34 4½ |
| Aug. 1 | 35 5 |
| Sept. 24 | 36 2½ |
| Dec. 10 | 36 2½ |

63. C. P. Brown, 2¼ miles SE. of Pomona.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Sept. 7 | 8 9 |
| Oct. 6 | 6 6½ |
| Nov. 16 | 3 10 |
| Dec. 13 | 3 3 |
| 1905. | |
| Jan. 11 | 2 5 |
| Feb. 20 | 2 0 |
| Mar. 10 | 2 ½ |
| Apr. 14 | 1 5 |
| May 17 | 2 0 |
| June 22 | 7 5 |
| July 20 | 12 10 |
| Aug. 16 | 12 2 |
| Sept. 20 | 11 10½ |
| Nov. 11 | 4 7½ |
| Dec. 20 | 4 1 |
| 1906. | |
| Jan. 26 | 4 3½ |
| Mar. 14 | 3 10 |
| May 8 | 4 4½ |
| June 26 | 13 10 |
| Aug. 1 | 15 8 |
| Sept. 24 | 13 6 |
| Dec. 10 | 4 10 |

*Tables showing variations of water in wells in southern California*—Continued.

64. Mr. Haley, ¼ mile W. of San Bernardino.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft.* |
| 1904. | |
| July 5 | 36.6 |
| Aug. 4 | 38.18 |
| Sept. 1 | 37.23 |
| Oct. 3 | 37.10 |
| Nov. 1 | 38.9 |
| Dec. 1 | 39.83 |
| 1905. | |
| Jan. 1 | 37.15 |
| Feb. 1 | 33.0 |
| Mar. 1 | 30.55 |
| Apr. 1 | 29.78 |
| May 1 | 30.1 |
| June 1 | 37.6 |
| July 1 | 39.0 |
| Oct. 1 | 40.5 |
| Nov. 1 | 36.8 |
| Dec. 1 | 33.7 |
| 1906. | |
| Jan. 1 | 33.7 |
| Feb. 1 | 33.0 |
| Mar. 1 | 32.0 |
| Apr. 1 | 31.38 |
| May 1 | 36.57 |
| June 1 | 35.7 |
| July 1 | 38.4 |
| Oct. 22 | 30.4 |

65. C. W. Rogers, 1 mile E. of Colton.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft.* |
| 1904. | |
| July 1 | 15.7 |
| Aug. 4 | 18.05 |
| Sept. 1 | 19.70 |
| Oct. 3 | 20.96 |
| Nov. 1 | 20.17 |
| Dec. 1 | 21.82 |
| 1905. | |
| Jan. 1 | 17.48 |
| Feb. 1 | 12.45 |
| Mar. 1 | 7.57 |
| Apr. 1 | 5.4 |
| May 1 | 5.6 |
| June 1 | 6.4 |
| July 1 | 9.3 |
| Aug. 1 | 12.75 |
| Sept. 1 | 15.9 |
| Oct. 1 | 18.45 |
| Nov. 1 | 18.28 |
| 1906. | |
| Jan. 1 | 14.34 |
| Feb. 1 | 12.58 |
| Mar. 1 | 8.35 |
| Apr. 1 | 5.40 |
| May 1 | 6.00 |
| June 1 | 5.9 |
| July 1 | 6.85 |
| Oct. 22 | 17.2 |

66. Riverside Water Co., 2 miles E. of Colton.

| Date of measurement. | Yield in miner's inches. |
|---|---|
| 1904. | |
| Aug. 1 | 3.69 |
| Sept. 1 | 4.4 |
| Oct. 3 | 5.16 |
| Nov. 1 | 4.4 |
| Dec. 1 | 5.16 |
| 1905. | |
| Jan. 1 | 5.16 |
| Feb. 1 | Capped. |
| Mar. 1 | Capped. |
| Apr. 1 | Capped. |
| May 1 | 5.16 |
| June 1 | 5.16 |
| July 1 | 7.5 |
| Aug. 1 | 5.16 |
| Sept. 1 | 3.7 |
| Oct. 1 | 4.12 |
| Nov. 1 | 4.32 |
| Dec. 1 | Capped. |
| 1906. | |
| Jan. 1 | Capped. |
| Feb. 1 | Capped. |
| Mar. 1 | Capped. |
| Apr. 1 | Capped. |
| May 1 | Capped. |
| June 1 | Capped. |
| July 1 | Capped. |
| Oct. 22 | 4.55 |

67. Riverside Water Co., Third and Waterman sts., San Bernardino.

| Date of measurement. | Yield in miner's inches. |
|---|---|
| 1904. | |
| Aug. 1 | 121.5 |
| Sept. 1 | 121.6 |
| Oct. 3 | 112.5 |
| Nov. 1 | 116.0 |
| Dec. 1 | 116.3 |
| 1905. | |
| Jan. 1 | 117.0 |
| Feb. 1 | Capped. |
| Mar. 1 | Capped. |
| Apr. 1 | Capped. |
| May 1 | Capped. |
| June 1 | 117.0 |
| July 1 | 118.4 |
| Aug. 1 | 116.7 |
| Sept. 1 | 111.6 |
| Oct. 1 | 115.1 |
| Nov. 1 | Capped. |
| Dec. 1 | Capped. |
| 1906. | |
| Jan. 1 | Capped. |
| Feb. 1 | Capped. |
| Mar. 1 | Capped. |
| Apr. 1 | Capped. |
| May 1 | Capped. |
| June 1 | Capped. |
| July 1 | 149.5 |
| Oct. 22 | 104.9 |

68. N. B. Hinkley estate, ¾ mile W. of Bryn Mawr.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft.* |
| 1904. | |
| July 1 | 85.9 |
| Aug. 4 | 82.7 |
| Sept. 1 | 84.5 |
| Oct. 3 | 80.0 |
| Nov. 1 | 80.6 |
| Dec. 1 | 80.8 |
| 1905. | |
| Jan. 1 | 81.0 |
| Feb. 1 | 80.8 |
| Mar. 1 | 80.7 |
| Apr. 1 | 79.0 |
| May 1 | 78.5 |
| June 1 | 78.0 |
| July 1 | 78.4 |
| Aug. 1 | 78.7 |
| Sept. 1 | 79.2 |
| Oct. 1 | 79.35 |
| Nov. 1 | 81.0 |
| Dec. 1 | 79.5 |
| 1906. | |
| Jan. 1 | 79.4 |
| Feb. 1 | 78.5 |
| Mar. 1 | 77.89 |
| Apr. 1 | 77.27 |
| May 1 | 74.66 |
| June 1 | 74.4 |
| July 1 | 74.2 |
| Oct. 22 | 75.7 |

69. Riverside County, 2½ miles S. of Alessandro.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft.* *in.* |
| 1904. | |
| Oct. 18 | 52 4½ |
| Nov. 18 | 51 10 |
| Dec. 15 | 51 7½ |
| 1905. | |
| Jan. 13 | 51 8½ |
| Feb. 22 | 50 5 |
| Mar. 24 | 49 6 |
| Apr. 19 | 49 2 |
| May 19 | 49 1 |
| July 22 | 50 4 |
| Aug. 18 | 50 8 |
| Sept. 22 | 50 11 |
| Nov. 9 | 51 ½ |
| 1906. | |
| May 11 | 51 9½ |
| June 29 | 52 4 |
| Aug. 3 | 52 9 |
| Sept. 26 | 52 8 |

*Tables showing variations of water in wells in southern California*—Continued.

70. 4 miles NE. of Perris.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 16 | 32 5 |
| 1905. | |
| Jan. 14 | 32 0 |
| Feb. 22 | 31 6 |
| Sept. 22 | 28 5 |
| Nov. 9 | 29 0 |
| Dec. 23 | 29 4 |
| 1906. | |
| Jan. 30 | 29 4 |
| Mar. 16 | 29 3 |
| May 11 | 29 7½ |
| Aug. 3 | 29 11½ |
| Sept. 26 | 30 ½ |
| Dec. 20 | 30 2½ |

71. C. Lossman, 2½ miles N. of Perris.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Dec. 15 | 63 3½ |
| 1905. | |
| Jan. 13 | 63 4½ |
| Feb. 22 | 63 0 |
| Mar. 26 | 62 6 |
| Apr. 19 | 62 3½ |
| May 19 | 62 0 |
| June 20 | 62 0 |
| July 22 | 62 2 |
| Aug. 19 | 62 2 |
| Sept. 22 | 62 3 |
| Nov. 9 | 62 5 |
| Dec. 23 | 62 5 |
| 1906. | |
| Mar. 16 | 62 4 |
| May 11 | 62 5 |
| June 29 | 62 5 |
| Aug. 3 | 63 2 |
| Sept. 26 | 63 4 |
| Dec. 20 | 63 4½ |

72. Crawford Carter, Perris.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Oct. 18 | 33 4 |
| Nov. 18 | 33 3 |
| Dec. 15 | 33 4 |
| 1905. | |
| Jan. 13 | 32 6 |
| Feb. 22 | 31 9½ |
| Mar. 26 | 30 10 |
| Apr. 18 | 30 7 |
| May 19 | 30 2½ |
| June 20 | 30 1 |
| July 23 | 30 4 |
| Sept. 22 | 30 6 |
| Nov. 9 | 30 11 |
| Dec. 22 | 31 4½ |
| 1906. | |
| Jan. 29 | 31 8 |
| Mar. 16 | 31 8 |
| June 28 | 31 2½ |
| Aug. 3 | 31 9 |
| Sept. 26 | 32 4½ |
| Dec. 20 | 32 3 |

73. Mrs. L. R. Harford, 3½ miles E. of Perris.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1901. | |
| May | 28 11 |
| 1902. | |
| July | 40 2 |
| Oct. 25 | 41 7 |
| Dec. 15 | 42 9 |
| 1903. | |
| Feb. 28 | 38 7 |
| Apr. 11 | 37 6 |
| May 14 | 38 2 |
| Sept. 15 | 43 4 |
| 1904. | |
| Jan. 31 | 43 4 |
| Feb. 28 | 41 11½ |
| Mar. 3 | 41 9 |
| Mar. 29 | 40 11 |
| May 1 | 42 10 |
| July 3 | 44 10 |
| Sept. 15 | 45 5 |
| 1905. | |
| Sept. 23 | 44 9 |
| Dec. 22 | 43 0 |
| 1906. | |
| Jan. 29 | 42 3 |
| Mar. 16 | 42 2 |
| May 12 | 40 2½ |
| June 28 | 38 8½ |
| Aug. 4 | 41 7 |
| Sept. 27 | 42 5½ |
| Dec. 21 | 43 6½ |

74. E. E. Waters, Ethanac.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Jan 29 | 44 2 |
| Feb. 27 | 41 4 |
| Mar. 27 | 40 5½ |
| Mar. 27 | 43 4 |
| May 27 | 41 7½ |
| July 2 | 46 0 |
| 1905. | |
| Feb. 20 | 44 8 |
| Apr. 5 | 43 1½ |
| June 18 | 45 5½ |
| Aug. 5 | 46 11 |
| Sept. 1 | 47 6 |
| Oct. 1 | 47 10 |
| Nov. 6 | 48 2 |
| Dec. 22 | 44 8 |
| 1906. | |
| Jan. 29 | 42 10 |
| Feb. 4 | 42 4 |
| Mar. 16 | 42 8 |
| May 12 | 41 2 |
| June 28 | 44 10½ |
| Aug. 4 | 45 0 |
| Sept. 27 | 47 6½ |
| Dec. 21 | 45 3 |

75. Temescal Water Co., 1¼ miles W. of Ethanac.

| Date of measurement. | Depth to water. |
|---|---|
| | *Ft. in.* |
| 1904. | |
| Oct. 18 | 29 10 |
| Nov. 18 | 30 4 |
| Dec. 15 | 30 7 |
| 1905. | |
| Jan. 13 | 30 3½ |
| Feb. 22 | 26 10½ |
| Mar. 26 | 25 10 |
| June 20 | 28 0 |
| July 23 | 28 9 |
| Aug. 19 | 29 5 |
| Sept. 23 | 29 8 |
| Nov. 10 | 30 3 |
| Dec. 22 | 29 8 |
| 1906. | |
| Jan. 29 | 29 7½ |
| Mar. 16 | 28 8½ |
| May 12 | 27 9 |
| June 28 | 27 9 |
| Aug. 4 | 28 7 |
| Sept. 27 | 30 1 |
| Dec. 21 | 30 2 |

*Tables showing variations of water in wells in southern California*—Continued.

76. Doctor Reese, 2¼ miles S. of Perris.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 18 | 21 10 |
| Nov. 18 | 19 0 |
| Dec. 15 | 18 9½ |
| 1905. | |
| Jan. 13 | 18 5 |
| Feb. 22 | 10 9 |
| Mar. 26 | 9 7½ |
| May 19 | 11 11 |
| June 20 | 13 4 |
| July 23 | 13 3 |
| Aug. 19 | 13 4 |
| Sept. 23 | 15 6 |
| Nov. 10 | 15 8 |
| Dec. 22 | 15 10½ |
| 1906. | |
| Jan. 29 | 15 9 |
| Mar. 16 | 15 7 |
| May 12 | 15 2 |
| June 28 | 15 5 |
| Sept. 27 | 16 2½ |

77. William Newport, 4½ miles S. of Perris.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 18 | 37 3 |
| Nov. 18 | 37 10 |
| Dec. 15 | 38 3 |
| 1905. | |
| Jan. 13 | 38 8 |
| Feb. 22 | 38 0 |
| Mar. 26 | 37 ½ |
| Apr. 18 | 36 7 |
| May 19 | 36 1½ |
| June 20 | 36 8½ |
| July 23 | 37 9 |
| Aug. 19 | 38 2 |
| Sept. 23 | 38 7½ |
| Nov. 10 | 39 5 |
| Dec. 22 | 39 4 |
| 1906. | |
| Jan. 29 | 38 6 |
| Mar. 16 | 38 5½ |
| May 12 | 37 4½ |
| June 28 | 36 3 |
| Aug. 4 | 37 0 |
| Sept. 27 | 38 0 |
| Dec. 21 | 38 5½ |

78. William Newport, Menifee Valley.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 18 | 28 2 |
| Nov. 18 | 28 3½ |
| Dec. 15 | 27 7 |
| 1905. | |
| Jan. 13 | 27 3½ |
| Feb. 22 | 24 ½ |
| Mar. 26 | 21 7½ |
| Apr. 18 | 21 9 |
| May 19 | 21 6 |
| June 20 | 21 9 |
| July 23 | 22 6 |
| Aug. 19 | 22 2 |
| Sept. 23 | 21 7 |
| Nov. 9 | 21 11 |
| Dec. 22 | 22 11 |
| 1906. | |
| Jan. 29 | 22 11 |
| Mar. 16 | 21 9 |
| May 12 | 19 10½ |
| June 28 | 19 10½ |
| Aug. 4 | 21 0 |
| Sept. 27 | 21 7 |
| Dec. 21 | 21 10 |

79. H. H. Lindenberger, 4 miles SW. of Winchester.

| Date of measurement. | Depth to water. |
|---|---|
| 1905. | *Ft. in.* |
| Feb. 22 | 23 4 |
| Mar. 25 | 22 5 |
| Apr. 18 | 20 3 |
| May 19 | 19 0 |
| July 23 | 19 0 |
| Sept. 23 | 18 7 |
| Nov. 10 | 18 6 |
| Dec. 22 | 18 3½ |
| 1906. | |
| Jan. 29 | 18 0 |
| Mar. 16 | 18 3 |
| May 12 | 16 9 |
| June 28 | 16 9 |
| Sept. 27 | 16 11½ |
| Dec. 21 | 16 10 |

80. M. M. Patterson, Winchester.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 18 | 24 3 |
| Nov. 18 | 23 5 |
| Dec. 15 | 22 6 |
| 1905. | |
| Jan. 13 | 22 3½ |
| Feb. 22 | 21 5 |
| Apr. 18 | 20 2 |
| May 19 | 20 2 |
| July 23 | 19 7 |
| Aug. 19 | 19 8 |
| Sept. 23 | 19 10 |
| Nov. 9 | 20 1 |
| Dec. 22 | 20 4 |
| 1906. | |
| Jan. 29 | 19 3 |
| May 12 | 20 0 |
| Aug. 4 | 19 11½ |
| Sept. 27 | 20 1 |
| Dec. 21 | 20 2½ |

81. Mrs. Maud F. Walker, 3 miles SW. of Hemet.

| Date of measurement. | Depth to water. |
|---|---|
| 1905. | *Ft. in.* |
| Mar. 25 | 14 6 |
| Apr. 18 | 10 6 |
| May 19 | 10 10 |
| June 20 | 10 6 |
| July 23 | 10 6 |
| Aug. 19 | 10 7½ |
| Sept. 23 | 11 1 |
| Nov. 10 | 10 11 |
| Dec. 22 | 11 2½ |
| 1906. | |
| Jan. 30 | 10 8 |
| Mar. 16 | 10 7 |
| May 12 | 10 4 |
| June 28 | 9 7 |
| Aug. 4 | 10 4 |
| Sept. 27 | 10 7 |
| Dec. 21 | 10 7 |

*Tables showing variations of water in wells in southern California*—Continued.

82. J. E. Garrigan, 1 mile W. of Hemet.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Dec. 15 | 33 3 |
| 1905. | |
| Jan. 14 | 33 5 |
| Feb. 23 | 33 3 |
| Mar. 25 | 33 1½ |
| Apr. 18 | 33 1 |
| May 18 | 33 0 |
| June 20 | 33 2 |
| July 23 | 33 1 |
| Aug. 19 | 34 0 |
| Sept. 23 | 33 6 |
| Nov. 10 | 33 0 |
| 1906. | |
| Jan. 30 | 32 9 |
| Mar. 17 | 32 5 |
| May 12 | 32 10½ |
| June 29 | 32 6 |
| Aug. 4 | 32 9 |
| Sept. 27 | 32 7½ |
| Dec. 20 | 32 6½ |

83. Mrs. Ruby Hewitt, ½ mile E. of Bowers.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 19 | 11 5 |
| Nov. 19 | 11 9 |
| Dec. 16 | 12 2 |
| 1905. | |
| Jan. 14 | 12 4 |
| Feb. 23 | 10 1 |
| Mar. 26 | 5 5 |
| Apr. 19 | 2 1 |
| May 19 | (*a*) |
| June 20 | (*a*) |
| July 22 | 0 7 |
| Aug. 18 | 1 8 |
| Sept. 22 | 3 2 |
| Nov. 10 | 4 7½ |
| Dec. 22 | 5 7½ |
| 1906. | |
| Jan. 30 | 6 5 |
| Mar. 17 | 5 6 |
| May 11 | (*b*) |
| June 29 | Flowing. |
| Aug. 3 | (*c*) |
| Sept. 26 | Flowing. |

84. J. Carmichael, Bowers.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Oct. 19 | 7 7½ |
| Nov. 19 | 7 10½ |
| Dec. 16 | 8 0 |
| 1905. | |
| Jan. 14 | 8 1 |
| Feb. 22 | 6 8 |
| Mar. 26 | 4 3 |
| Apr. 18 | 2 4 |
| May 19 | Flowing. |
| June 21 | Flowing. |
| July 22 | Flowing. |
| Aug. 18 | 3 9 |
| Sept. 22 | 2 6 |
| Nov. 10 | 2 9 |
| Dec. 22 | 3 1 |
| 1906. | |
| Jan. 30 | 2 9 |
| Mar. 17 | 2 8 |
| May 11 | Flowing. |
| Aug. 3 | Flowing. |
| Sept. 26 | Flowing. |
| Dec. 20 | Flowing. |

85. K. D. Harger, Lakeview.

| Date of measurement. | Depth to water. |
|---|---|
| 1904. | *Ft. in.* |
| Nov. 19 | 30 1 |
| Dec. 16 | 29 10 |
| 1905. | |
| Feb. 22 | 29 5 |
| Mar. 26 | 29 2½ |
| Apr. 19 | 29 0 |
| May 19 | 28 11 |
| June 21 | 28 10 |
| July 22 | 28 11 |
| Aug. 18 | 29 1 |
| Sept. 22 | 29 3 |
| Nov. 9 | 29 5 |
| Dec. 23 | 29 7 |
| 1906. | |
| Jan. 30 | 29 6 |
| May 11 | 29 2 |
| June 29 | 29 2 |
| Aug. 3 | 29 3½ |
| Sept. 26 | 29 5½ |
| Dec. 20 | 29 8 |

*a* Flowing good stream. *b* Flowing 5 miner's inches. *c* Flowing 7 miner's inches.

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# CLASSIFICATION OF THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 213.]

The publications of the United States Geological Survey consist of (1) Annual Reports; (2) Monographs; (3) Professional Papers; (4) Bulletins; (5) Mineral Resources; (6) Water-Supply and Irrigation Papers; (7) Topographic Atlas of United States, folios and separate sheets thereof; (8) Geologic Atlas of United States, folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists can be had on application.

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2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at practically cost.

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The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports; Q, Fuels; R, Structural materials.

*Series P.*—The hydrographic progress reports contain the results of stream measurements. A report is issued for every calendar year, containing the results of data collected during that year. These reports were first published as a part of the Director's annual report or as a bulletin; they are now published as water-supply and irrigation papers. The following is a list, by years, of the publications containing the progress reports of stream measurements (* means out of stock). A detailed index of these reports (1888–1903) is published as Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II*.
1889. Eleventh Annual Report, Part II*
1890. Twelfth Annual Report, Part II*.
1891. Thirteenth Annual Report, Part III*.
1892. Fourteenth Annual Report, Part II*.
1893. Bulletin No. 131*.
1894. Bulletin No. 131*; Sixteenth Annual Report, Part II*.
1895. Bulletin No. 140*.
1896. Water-Supply Paper No. 11*; Eighteenth Annual Report, Part IV*.
1897. Water-Supply Papers Nos. 15* and 16*; Nineteenth Annual Report, Part IV*.
1898. Water-Supply Papers Nos. 27* and 28*; Twentieth Annual Report, Part IV*.
1899. Water-Supply Papers Nos. 35*, 36*, 37*, 38*, and 39*; Twenty-first Annual Report, Part IV*.
1900. Water-Supply Papers Nos. 47, 48, 49, 50, 51, and 52; Twenty-second Annual Report, Part IV.
1901. East of Mississippi River, Water-Supply Papers Nos. 65* and 75*.
West of Mississippi River, Water-Supply Papers Nos. 66 and 75*.

1902. East of Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of Mississippi River, Water-Supply Papers Nos. 84 and 85.
1903. East of Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of Mississippi River, Water-Supply Papers Nos. 124, 125, 126, 127, 128, and 129.
West of Mississippi River, Water-Supply Papers Nos. 130, 131, 132, 133, 134, and 135.
1905. East of Mississippi River, Water-Supply Papers Nos. 165*, 166*, 167, 168*, 169, 170, and 171.
West of Mississippi River, Water-Supply Papers Nos. 171, 172*, 173*, 174, 175*, 176, 177, and 178.
1906. East of Mississippi River, Water-Supply Papers Nos. 201, 202, 203, 204, 205, 206, and 207.
West of Mississippi River, Water-Supply Papers Nos. 207, 208, 209, 210, 211, 212, 213, and 214.

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THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

OCTOBER, 1907.

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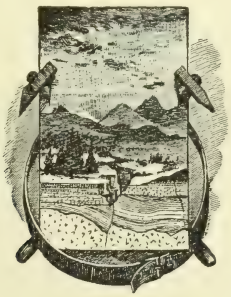
Water-Supply and Irrigation Paper No. 214 Series P, Hydrographic Progress Reports, 68

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

# SURFACE WATER SUPPLY OF THE NORTH PACIFIC COAST DRAINAGE, 1906

J. C. STEVENS, ROBERT FOLLANSBEE, and E. C. LA RUE
DISTRICT HYDROGRAPHERS

WORK IN OREGON DONE IN COOPERATION WITH THE STATE ENGINEER



WASHINGTON
GOVERNMENT PRINTING OFFICE
1907

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# SURFACE WATER SUPPLY OF THE NORTH PACIFIC COAST DRAINAGE, 1906.[a]

J. C. Stevens, Robert Follansbee, and E. C. La Rue,
*District Hydrographers.*[b]

## INTRODUCTION.

### SCOPE OF WORK.

The water supply of the United States is of more importance to the life and pursuits of the people than is any other natural resource. In the arid States the limit of agricultural development is determined by the amount of water available for irrigation, while in all parts of the country the increase in the population of cities and towns makes necessary additional water supplies for domestic and industrial uses, in procuring which both the quantity and the quality of the water that may be obtained must be considered. The location of manufacturing plants may depend largely on the water-power facilities and on the character of the water. The notable advances made in the electric transmission of power have led to the utilization of water powers for the operation of manufacturing establishments, railroads, and municipal lighting plants, many of which are at some distance from the places at which the power is developed.

The intelligent establishment and maintenance of enterprises or industries that depend on the use of water demands a thorough knowledge of the flow of the streams and an understanding of the conditions affecting that flow. This knowledge should be based on data showing

[a] The report contains information similar to that published in previous years under the title "Report of Progress of Stream Measurements."

[b] The data presented in this paper have been collected as follows:

Columbia River drainage in Oregon and Washington, and Puget Sound and Pacific Coast drainages north of the Oregon-California State line, by J. C. Stevens, district hydrographer, assisted by R. M. Hall, Ivan Landes, W. C. Muldrow, and H. D. McGlashan; in cooperation in Oregon with John H. Lewis, State engineer, assisted by L. R. Allen, Ivan E. Oakes, and Percy A. Cupper.

Clark Fork drainage by Robert Follansbee, district hydrographer.

Snake River drainage in Idaho and Wyoming by E. C. La Rue, district hydrographer.

The data have been prepared for publication under the direction of John C. Hoyt by R. H. Bolster, Robert Follansbee, F. F. Henshaw, J. E. Stewart, and H. D. Padgett.

both the total flow and the distribution of the flow throughout the year, in order that normal fluctuations may be provided for. As the flow of a stream is variable from year to year estimates of future flow can be made only from a study of observations covering several years. The rapid increase in the development of the water resources of the United States has caused a great demand by engineers for information in regard to the flow of streams, as it is now generally realized that the failure of many large power, irrigation, and other projects has been due to the fact that the plans were made without sufficient trustworthy information in respect to the water supply.

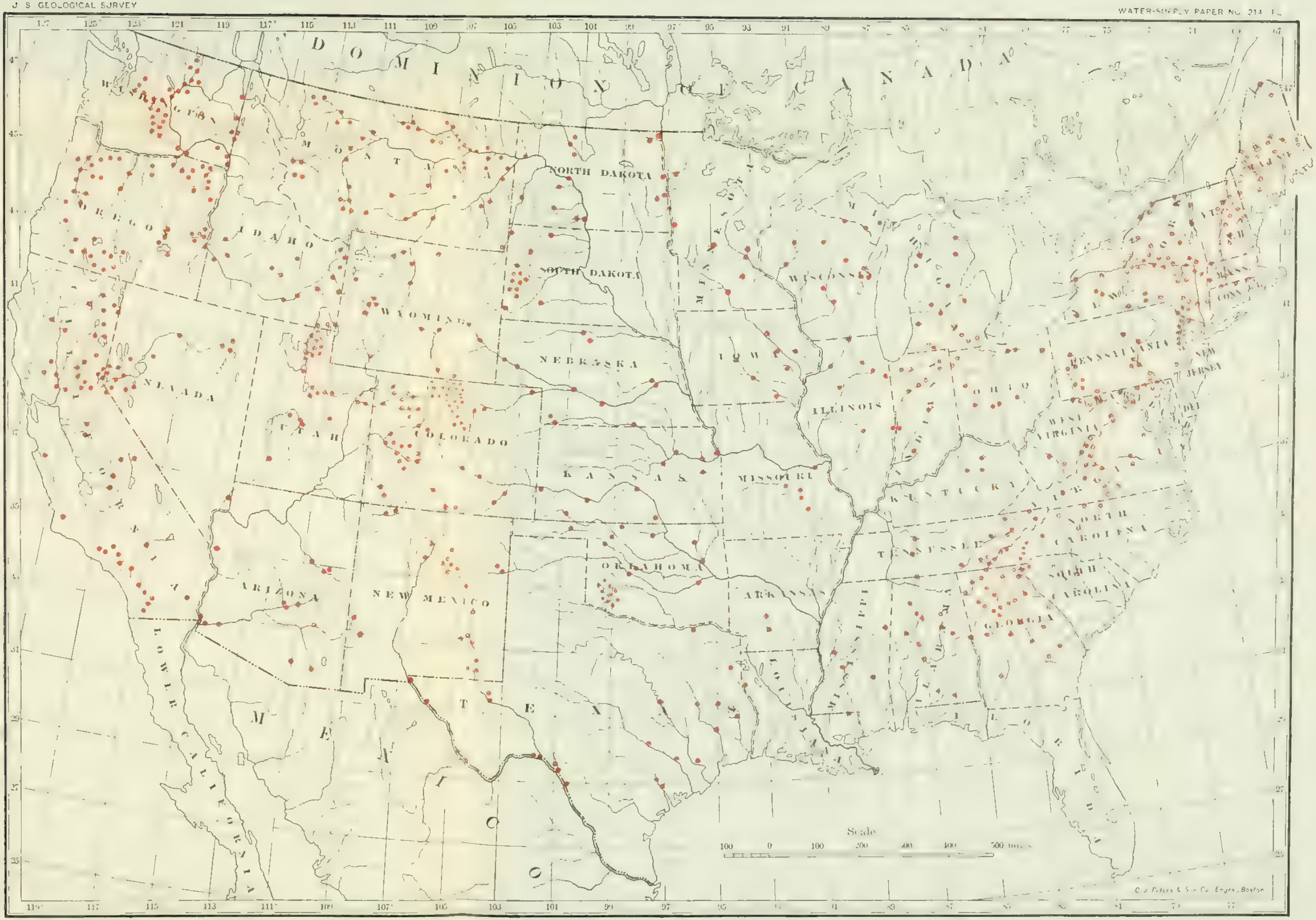
Owing to the broad scope of these hydrographic investigations and the length of time they should cover in order that the records may be of greatest value, it is, in general, impossible for private individuals to collect the necessary data, and as many of the streams traverse more than one State this work does not properly fall within the province of the State authorities. The United States Geological Survey has therefore, by means of specific appropriations by Congress, for several years systematically made records of stream flow, with the view of ultimately determining all the important features governing the flow of the principal streams of the country. In carrying out this plan stations are established on the streams and maintained for a period long enough to show their regimen or general behavior. When a record that is sufficient for this purpose has been obtained for any stream the work on that stream is discontinued. The order in which the streams are measured is determined by the degree of their importance.

During 1906 the regimen of flow was studied at about 700 stations distributed along the various rivers throughout the United States, as shown on Pl. I. In addition to these records data in regard to precipitation, evaporation, water power, and river profiles were obtained in many sections of the country.

These data have been assembled by drainage areas, and are published in a series of fourteen Water-Supply and Irrigation Papers, Nos. 201 to 214, inclusive, each of which pertains to the surface water resources of a group of adjacent areas. In these papers are embodied not only the data collected in the field, but also the results of computations based on these data, and other information that has a direct bearing on the subject, such as descriptions of basins and the streams draining them, utility of the water resources, etc. The list follows:

*Water-Supply and Irrigation Papers on surface water supply, 1906.*

201. Surface water supply of New England, 1906. (Atlantic coast of New England drainage.)
202. Surface water supply of the Hudson, Passaic, Raritan, and Delaware river drainages, 1906.
203. Surface water supply of the Middle Atlantic States, 1906. (Susquehanna, Gunpowder, Patapsco, Potomac, James, Roanoke, and Yadkin river drainages.)




MAP OF UNITED STATES SHOWING LOCATION OF PRINCIPAL RIVER STATIONS MAINTAINED DURING 1906.

204. Surface water supply of the Southern Atlantic and Eastern Gulf States, 1906. (Santee, Savannah, Ogeechee, and Altamaha rivers, and eastern Gulf of Mexico drainages.)
205. Surface water supply of the Ohio and lower eastern Mississippi river drainages, 1906.
206. Surface water supply of the Great Lakes and St. Lawrence River drainages, 1906.
207. Surface water supply of Hudson Bay and upper Mississippi River drainages, 1906.
208. Surface water supply of the Missouri River drainage, 1906.
209. Surface water supply of the lower western Mississippi River drainage, 1906.
210. Surface water supply of the western Gulf of Mexico and Rio Grande drainages, 1906.
211. Surface water supply of the Colorado River drainage above Yuma, 1906.
212. Surface water supply of the Great Basin drainage, 1906.
213. Surface water supply of California, 1906. (The Great Basin and Pacific Ocean drainage in California, and Colorado River drainage below Yuma.)
214. Surface water supply of the North Pacific Coast drainage, 1906.

The records at most of the stations discussed in these reports extend over a series of years. An index of the reports containing such records up to and including 1903 has been published in Water-Supply Paper No. 119. The following table gives, by years and primary drainage basins, the numbers of the papers on the surface water supply, published from 1901 to 1906.

*Number of Water-Supply Papers containing results of stream measurements, 1901–1906.*[a]

| | 1901. | 1902. | 1903. | 1904. | 1905. | 1906. |
|---|---|---|---|---|---|---|
| Atlantic coast of New England drainage | 65, 75 | 82 | 97 | 124 | 165 | 201 |
| Hudson, Passaic, Raritan, and Delaware river drainages | 65, 75 | 82 | 97 | 125 | 166 | 202 |
| Susquehanna, Gunpowder, Patapsco, Potomac, James, Roanoke, and Yadkin river drainages | 65, 75 | 82, 83 | 97, 98 | 126 | 167 | 203 |
| Santee, Savannah, Ogeechee, and Altamaha rivers, and eastern Gulf of Mexico drainages | 65, 75 | 83 | 98 | 127 | 168 | 204 |
| Ohio and lower eastern Mississippi river drainages | 65, 75 | 83 | 98 | 128 | 169 | 205 |
| Great Lakes and St. Lawrence River drainages | 65 | 83 | 97 | 129 | 170 | 206 |
| Hudson Bay and upper eastern and western Mississippi River drainages | 65, 66, 75 | 83, 84, 85 | 98, 99, 100 | 128, 130 | 171 | 207 |
| Missouri River drainage | 66, 75 | 84 | 99 | 130, 131 | 172 | 208 |
| Meramec, Arkansas, Red, and lower western Mississippi river drainages | 66, 75 | 84 | 99 | 131 | 173 | 209 |
| Western Gulf of Mexico and Rio Grande drainages | 66, 75 | 84 | 99 | 132 | 174 | 210 |
| Colorado River drainage above Yuma | 66, 75 | 85 | 100 | 133 | 175 | 211 |
| The Great Basin drainage | 66, 75 | 85 | 100 | 133 | 176 | 212 |
| The Great Basin and Pacific Ocean drainages in California, and Colorado River drainage below Yuma | 66, 75 | 85 | 100 | 134 | 177 | 213 |
| North Pacific Coast drainage | 66, 75 | 85 | 100 | 135 | 178 | 214 |

[a] Reports containing data for years prior to 1901 are noted in the series list at the end of this paper.

## DEFINITIONS.

The volume of water flowing in a stream—the "run-off" or "discharge"—is expressed in various terms, each of which has become associated with a certain class of work. These terms may be divided

into two groups: (1) Those which represent a rate of flow, as second-feet, gallons per minute, miner's inches, and run-off in second-feet per square mile; and (2) those which represent the actual quantity of water, as run-off in depth in inches and acre-feet. They may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second and is the quantity of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second. It is generally used as a fundamental unit from which others are computed.

"Gallons per minute" is generally used in connection with pumping and city water supply.

The "miner's inch" is the quantity of water that passes through an orifice 1 inch square under a head which varies locally. It has been commonly used by miners and irrigators throughout the West, and is defined by statute in each State in which it is used.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly, both as regards time and area.

"Run-off in inches" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

"Acre-foot" is equivalent to 43,560 cubic feet, and is the quantity required to cover an acre to the depth of 1 foot. It is commonly used in connection with storage for irrigation work. There is a convenient relation between the second-foot and the acre-foot: One second-foot flowing for twenty-four hours will deliver 86,400 cubic feet, or approximately 2 acre-feet.

## EXPLANATION AND USE OF TABLES.

For each regular gaging station are given, as far as available, the following data:

1. Description of station.
2. List of discharge measurements.
3. Gage-height table.
4. Rating table.
5. Table of monthly and yearly discharges and run-off.
6. Tables showing discharge and horsepower and the number of days during the year when the same are available.

The descriptions of stations give such general information about the locality and equipment as would enable the reader to find and

use the station, and they also give, as far as possible, a complete history of all the changes that have occurred since the establishment of the station that would be factors in using the data collected.

The discharge-measurement table gives the results of the discharge measurements made during the year, including the date, the name of the hydrographer, the width and area of cross section, the gage height, and the discharge in second-feet.

The table of daily gage heights gives the daily fluctuations of the surface of the river as found from the mean of the gage heights taken each day. The gage height given in the table represents the elevation of the surface of the water above the zero of the gage. At most stations the gage is read in the morning and in the evening.

The discharge measurements and gage heights are the base data from which the other tables are computed. In cases of extensive development it is expected that engineers will use these original data in making their calculations, as the computations made by the Survey are based on the data available at the time they are made and should be reviewed, and, if necessary, revised when additional data are available.

The rating table gives the discharge in second-feet corresponding to various stages of the river as given by the gage heights. It is published to enable engineers to determine the daily discharge, in case this information is desired.

In the table of monthly discharge, the column headed "Maximum" gives the mean flow for the day when the mean gage height was highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day, there might have been short periods when the water was higher and the corresponding discharge larger than given in this column. Likewise, in the column of "Minimum," the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow for each second during the month. Upon this the computations for the remaining columns, which are defined on page 4, are based.

The values in the table of monthly discharge are intended to give only a general idea of the conditions of flow at the station, and it is not expected that they will be used for other than preliminary estimates.

In most work where data in regard to flow are used the regimen of flow is of primary importance. Therefore, for the principal stations, tables have been prepared showing the horsepower that can be developed at various rates of flow, and the length of time that these rates of flow and the corresponding horsepower are available.

These tables have been prepared on a basis of 80 per cent efficiency on the turbines, and the horsepower per foot of fall is given in order that the reader can determine the horsepower for any fall.

In the computations, sufficient significant figures have been used so that the percentage of error in the tables will not in general exceed 1 per cent. Therefore, most of the values in the tables are given to only three significant figures. In making the various computations Thatcher's slide rule, Crelle's tables, and computation machines have been generally used.

In order to give engineers an idea of the relative value of the various data, notes in regard to accuracy are given as far as possible. This accuracy depends on the general local conditions at the gaging stations and the amount of data collected. Every effort possible is made to so locate the stations that the data collected will give a high degree of accuracy. This is not always possible but it is considered better to publish rough values with explanatory notes rather than no data.

In the accuracy notes the following terms have been used indicating the probable accuracy, in per cent, of the mean monthly flow. As these values are mean values, the error in the value for the flow of any individual day may be much larger.

Excellent indicates that the mean monthly flow is probably accurate to within 5 per cent; good, to within 10 per cent; fair, to within 15 per cent; approximate, to within 25 per cent.

## CONVENIENT EQUIVALENTS.

Following is a table of convenient equivalents for use in hydraulic computations:

1 second-foot equals 40 California miner's inches (law of March 23, 1901).
1 second-foot equals 38.4 Colorado miner's inches.
1 second-foot equals 40 Arizona miner's inches.
1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,272 gallons for one day.
1 second-foot equals 6.23 British imperial gallons per second.
1 second-foot for one year covers 1 square mile 1.131 feet deep, 13.572 inches deep.
1 second-foot for one year equals 31,536,000 cubic feet.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot for one day covers 1 square mile 0.03719 inch deep.
1 second-foot for one 28-day month covers 1 square mile 1.041 inches deep.
1 second-foot for one 29-day month covers 1 square mile 1.079 inches deep.
1 second-foot for one 30-day month covers 1 square mile 1.116 inches deep.
1 second-foot for one 31-day month covers 1 square mile 1.153 inches deep.
1 second-foot for one day equals 1.983 acre-feet.
1 second-foot for one 28-day month equals 55.54 acre-feet.
1 second-foot for one 29-day month equals 57.52 acre-feet.
1 second-foot for one 30-day month equals 59.50 acre-feet.
1 second-foot for one 31-day month equals 61.49 acre-feet.

100 California miner's inches equal 18.7 United States gallons per second.
100 California miner's inches equal 96.0 Colorado miner's inches.
100 California miner's inches for one day equal 4.96 acre-feet.
100 Colorado miner's inches equal 2.60 second-feet.
100 Colorado miner's inches equal 19.5 United States gallons per second.
100 Colorado miner's inches equal 104 California miner's inches.
100 Colorado miner's inches for one day equal 5.17 acre-feet.
100 United States gallons per minute equal 0.223 second-foot.
100 United States gallons per minute for one day equal 0.442 acre-foot.
1,000,000 United States gallons per day equal 1.55 second-feet.
1,000,000 United States gallons equal 3.07 acre-feet.
1,000,000 cubic feet equal 22.95 acre-feet.
1 acre-foot equals 325,850 gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-foot per year.
1 foot equals 0.3048 meter.
1 mile equals 1.60935 kilometers.
1 mile equals 5.280 feet.
1 acre equals 0.4047 hectare.
1 acre equals 43,560 square feet.
1 acre equals 209 feet square, nearly.
1 square mile equals 2.59 square kilometers.
1 cubic foot equals 0.0283 cubic meter.
1 cubic foot equals 7.48 gallons.
1 cubic foot of water weighs 62.5 pounds.
1 cubic meter per minute equals 0.5886 second-foot.
1 horsepower equals 550 foot-pounds per second.
1 horsepower equals 76.0 kilogram-meters per second.
1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.80 feet.
1⅓ horsepower equal about 1 kilowatt.

To calculate water power quickly: $\frac{\text{Sec.-ft.} \times \text{fall in feet}}{11} = \text{net horsepower on water wheel, realizing 80 per cent of theoretical power.}$

## FIELD METHODS OF MEASURING STREAM FLOW.

The methods used in collecting these data and in preparing them for publication are given in detail in Water-Supply Papers No. 94 (Hydrographic Manual, U. S. Geol. Survey) and No. 95 (Accuracy of Stream Measurements). In order that those who use this report may readily become acquainted with the general methods employed, the following brief descriptions are given:

Streams may be divided, with respect to their physical conditions, into three classes—(1) those with permanent beds; (2) those with beds which change only during extreme low or high water; (3) those with constantly shifting beds. In determining the daily flow special methods are necessary for each class. The data on which the determinations are based and the methods of collecting them are, however, in general the same.

There are three distinct methods of determining the flow of open-channel streams—(1) by measurements of slope and cross section and the use of Chezy's and Kutter's formulas; (2) by means of a weir; (3) by measurements of the velocity of the current and the area of the cross section. The method chosen for any case depends on the local physical conditions, the degree of accuracy desired, the funds available, and the length of time that the record is to be continued.

*Slope method.*—Much information has been collected relative to the coefficients to be used in the Chezy formula, $v = c\sqrt{R\,s}$. This has been utilized by Kutter, both in developing his formula for $c$ and in determining the values of the coefficient $n$ which appears therein. The results obtained by the slope method are in general only roughly approximate, owing to the difficulty in obtaining accurate data and the uncertainty of the value for $n$ to be used in Kutter's formula. The most common use of this method is in determining the flood discharge of a stream when the only data available are the cross section, the slope as shown by marks along the bank, and a knowledge of the general conditions.

*Weir methods.*—When funds are available and the conditions are such that sharp-crested weirs can be erected, these offer the best facilities for determining flow. If dams are suitably situated and constructed they may be utilized for obtaining reliable measurements of flow. The conditions necessary to insure good results may be divided into two classes—(1) those relating to the physical characteristics of the dam itself, and (2) those relating to the diversion and use of water around and through the dam.

The physical requirements are as follows: (*a*) Sufficient height of dam, so that backwater will not interfere with free fall over it; (*b*) absence of leaks of appreciable magnitude; (*c*) topography or abutments which confine the flow over the dam at high stages; (*d*) level crests, which are kept free from obstructions caused by floating logs or ice; (*e*) crests of a type for which the coefficients to be used in $Q = c\,b\,h^{\frac{3}{2}}$, or some similar standard weir formula, are known (see Water-Supply Papers Nos. 180 and 200[a]); (*f*) either no flashboards or exceptional care in reducing leakage through them and in recording their condition.

Preferably there should be no diversion of water through or around the dam. Generally, however, the dam is built for purposes of power or navigation, and part or all of the water flowing past it is diverted for such uses. This water is measured and added to that passing over the dam. To insure accuracy in such determinations of flow the amount of water diverted should be reasonably constant. Furthermore, it should be so diverted that it can be measured, either by

[a] Water-Supply Paper No. 200 replaces No. 150, the edition of which has been exhausted.

a weir, a current meter, or a simple system of water wheels which are of standard make, or which have been rated as meters under working conditions and so installed that the gate openings, the heads under which they work, and their angular velocities may be accurately observed.

The combination of physical conditions and uses of water should be such that the determinations of flow will not involve, for a critical stage of considerable duration, the use of a head on a broad-crested dam, of less than 6 inches. Moreover, when all other conditions are good, the cooperation of the owners or operators of the plant is still essential if reliable results are to be obtained.

A gaging station at a weir or dam has the general advantage of continuity of record through the periods of ice and floods, and the disadvantages of uncertainty of coefficient to be used in the weir formula and of complications in the diversion and use of the water.

*Velocity method.*—The determination of the quantity of water flowing past a certain section of a stream at a given time is termed a discharge measurement. This quantity is the product of two factors—the mean velocity and the area of the cross section. The mean velocity is a function of surface slope, wetted perimeter, roughness of bed, and the channel conditions at, above, and below the gaging section. The area depends on the contour of the bed and the fluctuations of the water surface. The two principal ways of measuring the velocity of a stream are by floats and current meters.

Great care is taken in the selection and equipment of gaging stations for determining discharge by velocity measurements in order that the data may have the required degree of accuracy. Their essential requirements are practically the same whether the velocity is determined by meters or floats. They are located as far as possible where the channel is straight both above and below the gaging section; where there are no cross currents, backwater, or boils; where the bed of the stream is reasonably free from large projections of a permanent character; and where the banks are high and subject to overflow only at flood stages. The station must be so far removed from the effects of tributary streams and of dams or other artificial obstructions that the gage height shall be an index of the discharge.

Certain permanent or semipermanent structures, usually referred to as "equipment," are generally pertinent to a gaging station. These are a gage for determining the fluctuations of the water surface, bench marks to which the datum of the gage is referred, permanent marks on a bridge or a tagged line indicating the points of measurement, and, where the current is swift, some appliance (generally a secondary cable) to hold the meter in position in the water. As a rule, the stations are located at bridges if the channel conditions are satisfactory,

as from them the observations can more readily be made and the cost of the equipment is small.

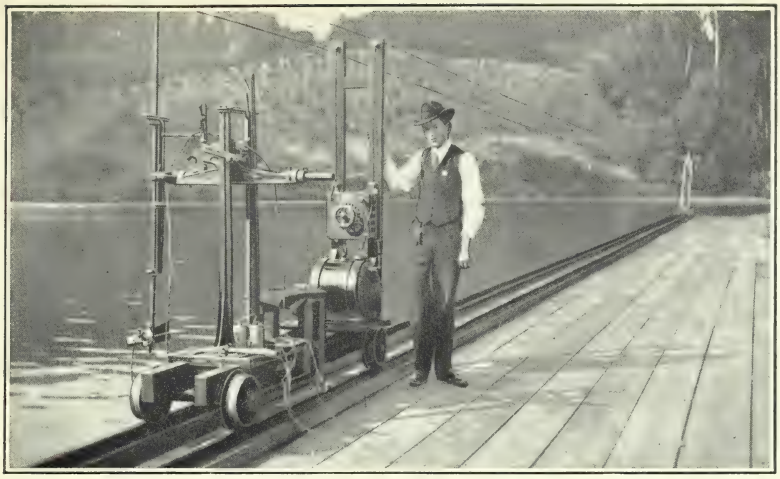
The floats in common use are the surface, subsurface, and tube or rod floats. A corked bottle with a flag in the top and weighted at the bottom makes one of the most satisfactory surface floats, as it is affected but little by wind. In case of flood measurements, good results can be obtained by observing the velocity of floating cakes of ice or débris. In case of all surface-float measurements coefficients must be used to reduce the observed velocity to the mean velocity. The subsurface and tube or rod floats are intended to give directly the mean velocity in the vertical. Tubes give excellent results when the channel conditions are good, as in canals.

In measuring velocity by a float, observation is made of the time taken by the float to pass over the "run," a selected stretch of river from 50 to 200 feet long. In each discharge measurement a large number of velocity determinations are made at different points across the stream, and from these observations the mean velocity for the whole section is determined. This may be done by plotting the mean positions of the floats as indicated by the distances from the bank as ordinates and the corresponding times as abscissas. A curve through these points shows the mean time of run at any point across the stream, and the mean time for the whole stream is obtained by dividing the area bounded by this curve and its axis by the width. The length of the run divided by the mean time gives the mean velocity.

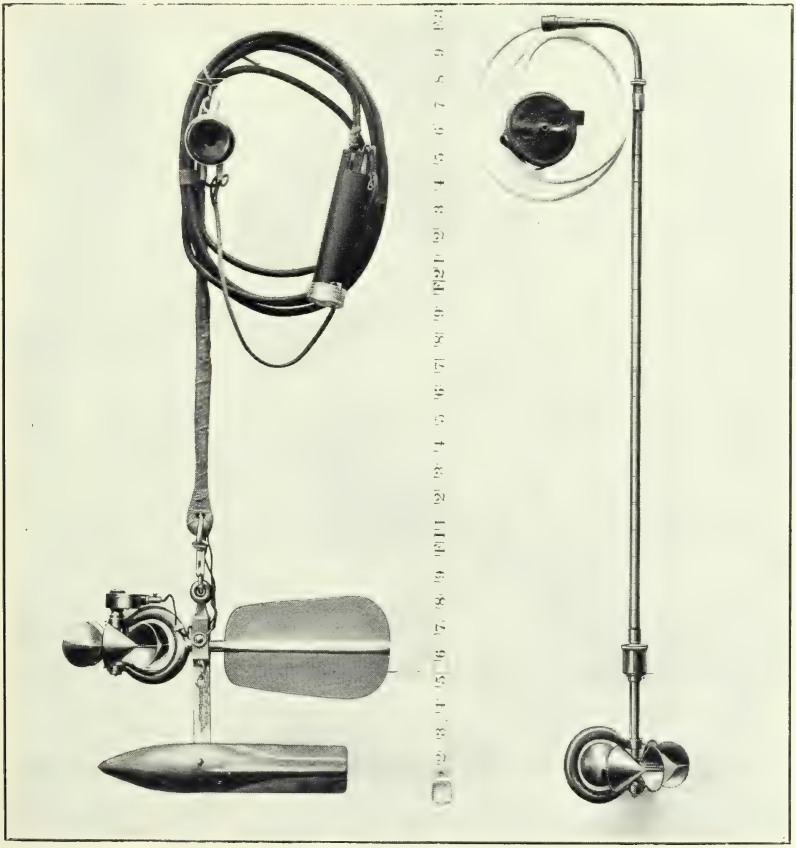
The area used in float measurements is the mean of the areas at the two ends of the run and at several intermediate sections.

The essential parts of the current meters in use are a wheel of some type so constructed that the impact of flowing water causes it to revolve and a device for recording or indicating the number of revolutions. The relation between the velocity of the moving water and the revolutions of the wheel is determined for each meter. This rating is done by drawing the meter through still water for a given distance at different speeds and noting the number of revolutions for each run. From these data a rating table is prepared which gives the velocity per second for any number of revolutions.

Many kinds of current meters have been constructed. They may, however, be classed in two general types—those in which the wheel is made up of a series of cups, as the Price, and those having a screw-propeller wheel, as the Haskell. Each meter has been developed for use under some special condition. In the case of the small Price meter, shown in Pl. II, *B*, which has been largely developed and extensively used by the United States Geological Survey, an attempt has been made to get an instrument which could be used under practically all conditions.



*A*. CURRENT-METER RATING STATION, LOS ANGELES, CAL.



*B*. PRICE CURRENT METERS.

Current-meter measurements may be made from a bridge, cable, boat, or by wading, and gaging stations may be classified in accordance with such use. Fig. 1 shows a typical cable station.

In making the measurement an arbitrary number of points are laid off on a line perpendicular to the thread of the stream. The points at which the velocity and depth are observed are known as measuring points and are usually fixed at regular intervals, varying from 2 to 20 feet, depending on the size and condition of the stream. Perpendiculars dropped from the measuring points divide the gaging section into strips. For each strip or pair of strips the mean velocity, area, and discharge are determined independently, so that conditions existing in one part of the stream may not be extended to parts where they do not apply.

Three classes of methods of measuring velocity with current meters are in general use—multiple-point, single-point, and integration.

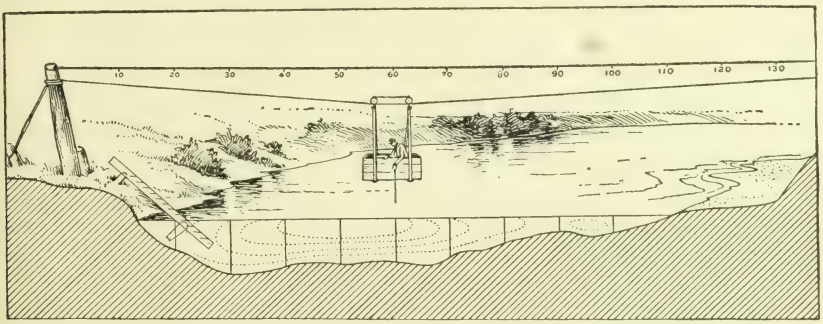



FIG. 1.—Cable station showing section of the river, car, gage, etc.

The three principal multiple-point methods in general use are the vertical velocity-curve; 0.2 and 0.8 depth; and top, bottom, and mid-depth.

In the vertical velocity-curve method a series of velocity determinations are made in each vertical at regular intervals, usually from 0.5 to 1 foot apart. By plotting these velocities as abscissas and their depths as ordinates and drawing a smooth curve among the resulting points the vertical velocity-curve is developed. This curve shows, graphically, the magnitude and changes in velocity from the surface to the bottom of the stream. The mean velocity in the vertical is then obtained by dividing the area bounded by this velocity curve and its axis by the depth. On account of the length of time required to make a complete measurement by this method its use is limited to the determination of coefficients for purposes of comparison and to measurements under ice.

In the second multiple-point method the meter is held successively at 0.2 and 0.8 of the depth, and the mean of the velocities at these two

points is taken as the mean velocity for that vertical. On the assumption that the vertical velocity-curve is a common parabola with horizontal axis, the mean of the velocities at 0.22 and 0.79 of the depth will give (closely) the mean velocity in the vertical. Actual observations under a wide range of conditions show that this second multiple-point method gives the mean velocity very closely for open-water conditions, and, moreover, the indications are that it holds nearly as well for ice-covered rivers.

In the third multiple-point method the meter is held at mid-depth, at 0.5 foot below the surface, and at 0.5 foot above the bottom, and the mean velocity is determined by dividing by 6 the sum of the top velocity, four times the mid-depth velocity, and the bottom velocity. The method may be modified by observing at 0.2, 0.6, and 0.8 depth.

The single-point method consists in holding the meter either at the depth of the thread of mean velocity or at an arbitrary depth for which the coefficient for reducing to mean velocity has been determined.

Extensive experiments by vertical velocity-curves show that the thread of mean velocity generally occurs at from 0.3 to 0.7 of the total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, at which point the meter is held in a majority of the measurements. A large number of vertical velocity-curve measurements, taken on many streams and under varying conditions, show that the average coefficient for reducing the velocity obtained at 0.6 depth to mean velocity is practically unity.

In the other principal single-point method the meter is held near the surface, usually 1 foot below or low enough to be out of the effect of the wind or other disturbing influences. This is known as the subsurface method. The coefficient for reducing the velocity taken at the subsurface to the mean has been found to be from 0.85 to 0.95, depending on the stage, velocity, and channel conditions. The higher the stage the larger the coefficient. This method is specially adapted for flood measurements or when the velocity is so great that the meter can not be kept at 0.6 depth.

The vertical-integration method consists in moving the meter at a slow uniform speed from the surface to the bottom and back again to the surface and noting the number of revolutions and the time taken in the operation. This method has the advantage that the velocity at each point of the vertical is measured twice. It is useful as a check on the point methods.

The area, which is the other factor in the velocity method of determining the discharge of a stream, depends on the stage of the river, which is observed on the gage, and on the general contour of the bed of the stream, which is determined by soundings. The soundings are usually taken at each measuring point at the time of the discharge

measurement either by using the meter and cable or by a special sounding line or rod. For streams with permanent beds standard cross sections are usually taken during low water. These sections serve to check the soundings which are taken at the time of the measurements, and from them any change which may have taken place in the bed of the stream can be detected. They are also of value in obtaining the area for use in computations of high-water measurements, as accurate soundings are hard to obtain at high stages.

In computing the discharge measurements from the observed velocities and depths at various points of measurement the measuring section is divided into elementary strips, as shown in fig. 1, and the mean velocity, area, and discharge are determined separately for either a single or a double strip. The total discharge and the area are the sums of those for the various strips, and the mean velocity is obtained by dividing the total discharge by the total area.

The determination of the flow of an ice-covered stream is difficult, owing to diversity and instability of conditions during the winter period, and also to lack of definite information in regard to the laws of flow of water under ice. The method now employed is to make frequent discharge measurements during the frozen periods by the 0.2 and 0.8, and vertical velocity-curve methods, and to keep an accurate record of the conditions, such as the gage height to the surface of the water as it rises in a hole cut in the ice, the thickness and character of the ice, etc. From these data an approximate estimate of the daily flow can be made by constructing a rating curve (really a series of curves) similar to that used for open channels, but considering, in addition to gage heights and discharge, the varying thickness of ice.

For information in regard to flow under ice cover see Water-Supply Paper No. 187.

## OFFICE METHODS OF COMPUTING RUN-OFF.

There are two principal methods of determining run-off, depending upon whether or not the bed of the stream is permanent.

For stations of streams with permanent beds the first step in computing the run-off is the construction of a rating table, which shows the discharge corresponding to any stage of the stream. This rating table is applied to the record of stage to determine the amount of water flowing. The construction of the rating table depends on the method used in measuring flow.

For a station at a weir or dam the basis for the rating table is some standard weir formula. The coefficients to be used in its application depend on the type of dam and other conditions near its crest. After inserting in the weir formula the measured length of crest and the

assumed coefficient, the discharge is computed for various heads and the rating table constructed.

The data necessary for the construction of a rating table for a velocity-area station are the results of the discharge measurements, which include the record of stage of the river at the time of measurement, the area of the cross section, the mean velocity of the current, and the quantity of water flowing. A thorough knowledge of the conditions at and in the vicinity of the station is also necessary.

The construction of the rating table depends on the following laws of flow for open permanent channels: (1) The discharge will remain constant so long as conditions at or near the gaging station remain constant. (2) The discharge will be the same whenever the stream is at a given stage if the change of slope due to the rise and fall of the stream be neglected. (3) The discharge is a function of and increases gradually with the stage.

The plotting of results of the various discharge measurements, using gage heights as ordinates; and discharge, mean velocity, and area as abscissas will define curves which show the discharge, mean velocity, and area corresponding to any gage height. For the development of these curves there should be, therefore, a sufficient number of discharge measurements to cover the range of the stage of the stream. Fig. 2 shows a typical rating curve with its corresponding mean-velocity and area curves.

As the discharge is the product of two factors, the area and the mean velocity, any change in either factor will produce a corresponding change in the discharge. Their curves are therefore constructed in order to study each independently of the other.

The area curve can be definitely determined from accurate soundings extending to the limits of high water. It is always concave toward the horizontal axis or on a straight line, unless the banks of the stream are overhanging.

The form of the mean-velocity curve depends chiefly on the surface slope, the roughness of the bed, and the cross section of the stream. Of these, the slope is the principal factor. In accordance with the relative changes of these factors the curve may be either a straight line, convex or concave toward either axis, or a combination of the three. From a careful study of the conditions at any gaging station the form which the vertical velocity-curve will take can be predicted, and it may be extended with reasonable certainty to stages beyond the limits of actual measurements. Its principal use is in connection with the area curve in locating errors in discharge measurements and in constructing the rating table.

The discharge curve is defined primarily by the measurements of discharge, which are studied and weighted in accordance with the local conditions existing at the time of each measurement. The curve may,

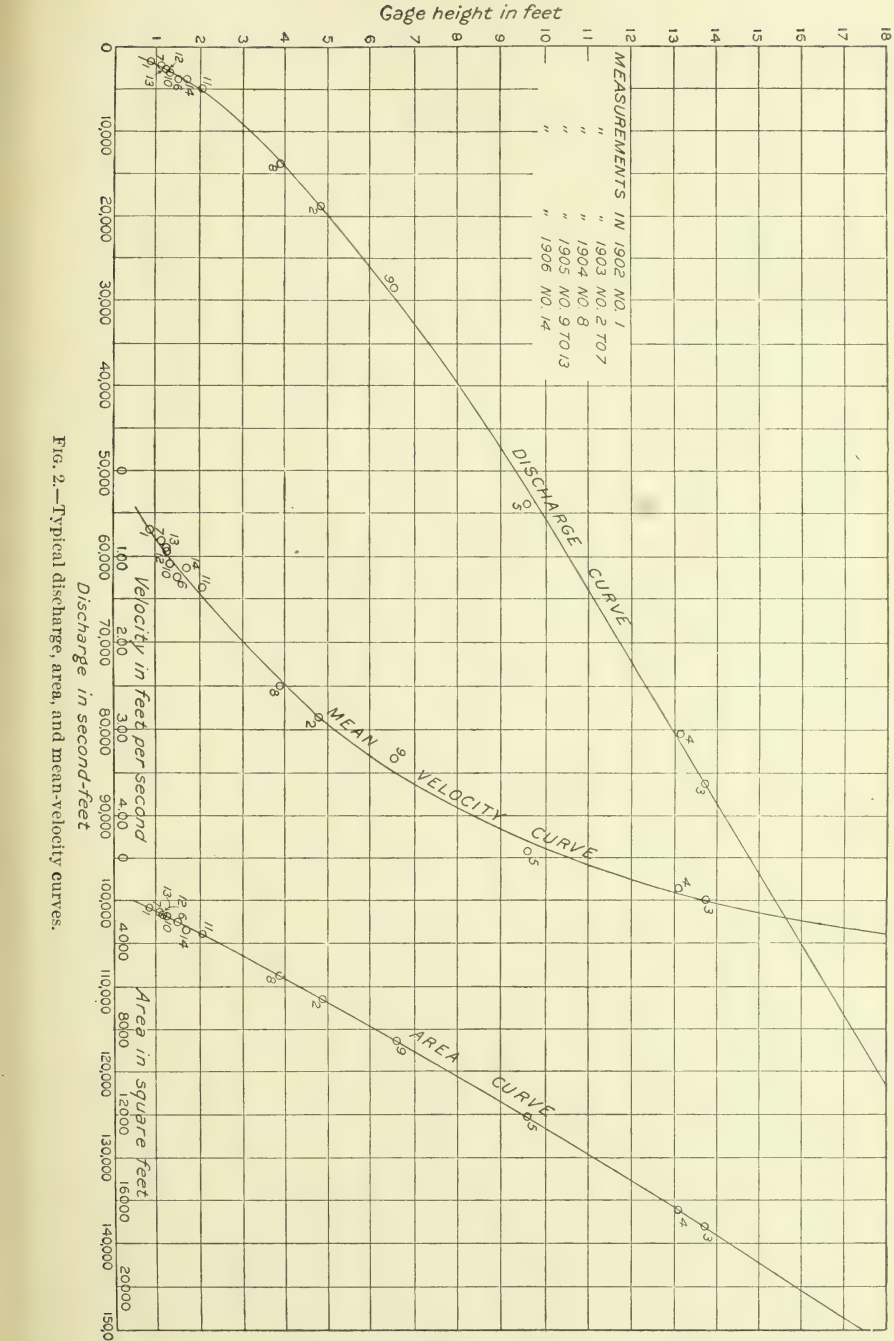

Gage height in feet
MEASUREMENTS IN 1902 NO. 1
" 1903 NO. 2 TO 7
" 1904 NO. 8
" 1905 NO. 9 TO 13
" 1906 NO. 14
DISCHARGE CURVE
MEAN VELOCITY CURVE
AREA CURVE
Velocity in feet per second
Area in square feet
Discharge in second-feet

FIG. 2.—Typical discharge, area, and mean-velocity curves.

however, best be located between and beyond the measurements by means of curves of area and mean velocity. The discharge curve under normal conditions is concave toward the horizontal axis and is generally parabolic in form.

In the preparation of the rating table the discharge for each tenth or half tenth on the gage is taken from the curve. The differences between successive discharges are then taken and adjusted according to the law that they shall be either constant or increasing.

The determination of daily discharge of streams with changeable beds is a difficult problem. In case there is a weir or dam available, a condition which seldom exists on streams of this class, the discharge can be determined by its use. In case of velocity-area stations frequent discharge measurements must be made if the determinations of flow are to be other than rough approximations. For stations with beds which shift slowly, or are materially changed only during floods, rating tables can be prepared for periods between such changes and satisfactory results obtained with a limited number of measurements, provided that some of them are taken soon after the change occurs. For streams with continually shifting beds, such as the Colorado and Rio Grande, discharge measurements should be made every two or three days and the discharges for intervening days obtained either by interpolation modified by gage height or by Professor Stout's method, which has been described in full in the Nineteenth Annual Report of the United States Geological Survey, Part IV, page 323, and in the Engineering News of April 21, 1904. This method, or a graphical application of it, is also much used in determining the flow at stations where the bed shifts but slowly.

## COOPERATION AND ACKNOWLEDGMENTS.

Special acknowledgments are due to John H. Lewis, State engineer of Oregon, for cooperation in accordance with the provisions of section 10, chapter 228, Laws of Oregon for 1905, "Hydrographic and topographic surveys in cooperation with the United States Government," which provides $2,500 annually for hydrographic surveys, "such appropriations, however, being contingent upon the United States Government making a like apportionment for such purposes to be expended within the State."

In 1906 the cooperative fund of $2,500 appropriated by the State of Oregon was largely spent under the direction of the State engineer in western Oregon, the Geological Survey retaining supervision of the work and publishing the results without expense to the State; but the Federal Survey, realizing the benefits to be derived by a more extensive study of the water resources of the State than could be accomplished by merely meeting the State's appropriation,

expended on hydrographic work in Oregon the sum of $5,533 during the calendar year 1906.

Assistance has been rendered or records furnished by the following, to whom acknowledgments are due:

The officers and employees of the United States Weather Bureau; Corps of Engineers, U. S. Army; Meteorological Service of Department of Marine and Fisheries, Canada; for climatological and hydrographic data.

Oregon Railroad and Navigation Company; Southern Pacific Company; Oregon Short Line Railroad; Northern Pacific Railroad; Sumpter Valley Railway; and Columbia Southern Railway; for transportation.

J. G. Kelley, Portland, Oreg.; Charles Gilman Hyde, University of California, Berkeley; R. H. McKee, Seattle, Wash.; Frank C. Kelsey and Williard Young, Portland, Oreg.; for results of measurements and other hydrographic data, collected by them and furnished gratis.

Deschutes Irrigation and Power Company, Portland, Oreg.; Columbia Southern Irrigating Company, Portland, Oreg.; Squaw Creek Irrigation Company, Prineville, Oreg.; Lewiston-Clarkston Company, Clarkston, Wash.; Seattle-Tacoma Power Company, Seattle, Wash.; Northwestern Gas and Electric Company, Pendleton, Oreg.; Condor Water and Power Company, Tolo, Oreg.; M. W. Zindel, Zindel, Wash.; and the citizens of Union, Oreg., and Sisters, Oreg.; for voluntary observations of gage heights.

## COLUMBIA RIVER DRAINAGE.

### COLUMBIA RIVER PROPER.

#### DESCRIPTION OF BASIN.

Columbia River has its source in Columbia Lake in the east division of the Kootenai district in British Columbia; thence it flows northward to the fifty-second parallel of latitude, where it turns sharply southward and flows through a series of arrowlike lakes, crossing the international boundary line in the northeast corner of the State of Washington, where it receives the Clark Fork. After traversing the State of Washington it forms the boundary line between Washington and Oregon and empties into the Pacific Ocean at the forty-sixth parallel of latitude. The river is navigable in long stretches throughout its entire course in the United States, although, owing to rapids and falls, continuous navigation is not possible.

The Columbia and its tributaries drain a total area of 259,000 square miles, distributed as follows:

*Areas in Columbia River basin.*

| | Square miles. |
|---|---|
| Oregon | 55,370 |
| Washington | 48,000 |
| Idaho | 81,380 |
| Montana | 25,000 |
| Nevada | 5,280 |
| Wyoming | 5,270 |
| British Columbia | 38,700 |

The larger part of this area is arid or semiarid, the annual rainfall varying from 10 inches in portions of Oregon and Idaho to 100 inches on the Cascade Range. The area is largely mountainous, and the streams flow for the most part through deep canyons in the basaltic formations characteristic of the Pacific Northwest. The flood discharge of the Columbia at The Dalles has been estimated at 1,000,000 second-feet and the low-water flow at about 40,000 second-feet.

The tributaries of the Columbia are of great importance, affording good sites for the development of power and an abundance of water for irrigation, which latter is extensively practiced in some of the valleys, notably those of Umatilla, Yakima, and the upper portion of Snake River.

The basins of Naches, Boise, and Walla Walla rivers and other tributary streams are described in connection with gaging stations maintained on them.

On the Columbia proper but one gaging station—that at Pasco—is maintained by the Geological Survey. Others, however, are maintained by the United States Weather Bureau at Riparia, Wenatchee, Umatilla, The Dalles, and Vancouver, and by the United States Corps of Engineers at Celilo, Cascade Locks, and Fort Stevens.

### COLUMBIA RIVER AT PASCO, WASH.

This station was established October 15, 1904, at the bridge of the Northern Pacific Railway, 1.2 miles from Pasco, Wash. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 13, where are given also references to publications that contain data for previous years.

*Daily gage height, in feet, of Columbia River at Pasco, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.7 | 8.0 | 9.3 | 11.4 | 17.8 | 21.0 | 19.7 | 17.5 | 12.9 | 11.6 | 11.0 | 11.8 |
| 2 | 7.7 | 8.1 | 9.2 | 12.2 | 18.1 | 20.9 | 19.7 | 17.4 | 12.8 | 11.5 | 10.8 | 11.7 |
| 3 | 7.6 | 8.2 | 9.2 | 13.0 | 18.5 | 20.8 | 19.7 | 17.4 | 12.8 | 11.4 | 10.8 | 11.6 |
| 4 | 7.6 | 8.2 | 9.2 | 13.0 | 18.8 | 20.8 | 19.7 | 17.2 | 12.8 | 11.3 | 10.8 | 11.4 |
| 5 | 7.6 | 8.3 | 9.1 | 12.8 | 19.2 | 21.0 | 19.7 | 17.0 | 12.7 | 11.2 | 10.7 | 11.3 |
| 6 | 7.6 | 8.3 | 9.0 | 12.6 | 19.3 | 21.0 | 19.7 | 16.8 | 12.7 | 11.1 | 10.6 | 11.2 |
| 7 | 7.5 | 8.2 | 9.0 | 12.6 | 19.2 | 21.1 | 19.7 | 16.5 | 12.7 | 11.0 | 10.6 | 11.1 |
| 8 | 7.5 | 8.1 | 8.9 | 13.0 | 19.1 | 21.1 | 19.8 | 16.1 | 12.6 | 10.9 | 10.6 | 11.1 |
| 9 | 7.5 | 8.1 | 9.0 | 13.4 | 19.0 | 21.0 | 19.9 | 15.9 | 12.6 | 10.9 | 10.7 | 11.1 |
| 10 | 7.5 | 8.0 | 9.1 | 13.9 | 19.0 | 20.9 | 20.1 | 15.6 | 12.5 | 10.8 | 10.9 | 11.1 |
| 11 | 7.4 | 7.9 | 9.1 | 14.4 | 19.3 | 20.8 | 20.3 | 15.4 | 12.5 | 10.7 | 10.7 | 11.0 |
| 12 | 7.4 | 7.9 | 9.2 | 14.4 | 19.7 | 20.8 | 20.4 | 15.3 | 12.8 | 10.6 | 10.8 | 11.0 |
| 13 | 7.4 | 7.9 | 9.2 | 14.3 | 20.1 | 20.9 | 20.5 | 15.1 | 13.2 | 10.6 | 10.9 | 11.0 |
| 14 | 7.5 | 7.9 | 9.0 | 14.1 | 20.3 | 21.1 | 20.6 | 15.0 | 13.5 | 10.5 | 11.4 | 11.0 |
| 15 | 7.5 | 7.9 | 8.9 | 13.8 | 20.3 | 21.1 | 20.6 | 15.0 | 13.7 | 10.5 | 14.0 | 10.9 |
| 16 | 7.5 | 7.8 | 8.8 | 13.8 | 20.2 | 21.0 | 20.6 | 15.0 | 13.7 | 10.5 | 16.6 | 10.8 |
| 17 | 7.4 | 7.8 | 8.7 | 14.0 | 20.2 | 21.0 | 20.5 | 15.0 | 13.5 | 10.5 | 17.5 | 10.6 |
| 18 | 7.4 | 7.8 | 8.4 | 14.3 | 20.1 | 21.1 | 20.4 | 15.0 | 13.3 | 10.5 | 16.3 | 10.6 |
| 19 | 7.4 | 7.8 | 8.3 | 14.6 | 20.0 | 20.9 | 20.2 | 15.0 | 13.1 | 10.6 | 15.3 | 10.5 |
| 20 | 7.4 | 8.0 | 8.3 | 14.9 | 20.0 | 20.7 | 20.0 | 15.0 | 12.8 | 10.6 | 14.0 | 10.4 |
| 21 | 7.4 | 8.8 | 8.3 | 15.1 | 19.9 | 20.5 | 19.9 | 14.9 | 12.6 | 10.6 | 13.3 | 10.6 |
| 22 | 7.4 | 9.0 | 8.3 | 15.3 | 19.9 | 20.1 | 19.7 | 14.7 | 12.4 | 10.6 | 13.1 | 11.4 |
| 23 | 7.3 | 9.2 | 8.3 | 15.9 | 19.9 | 20.0 | 19.4 | 14.6 | 12.2 | 10.6 | 12.9 | 11.4 |
| 24 | 7.4 | 9.3 | 8.3 | 16.6 | 19.9 | 19.8 | 19.2 | 14.4 | 12.0 | 10.5 | 12.8 | 11.3 |
| 25 | 7.4 | 9.3 | 8.4 | 17.2 | 19.9 | 19.5 | 19.0 | 14.3 | 12.0 | 10.5 | 12.6 | 11.3 |
| 26 | 7.6 | 9.3 | 8.7 | 17.6 | 20.0 | 19.5 | 18.8 | 14.0 | 12.0 | 10.4 | 12.4 | 11.4 |
| 27 | 7.8 | 9.3 | 9.4 | 17.6 | 20.2 | 19.3 | 18.6 | 13.8 | 11.9 | 10.3 | 12.2 | 11.7 |
| 28 | 8.0 | 9.3 | 10.2 | 17.5 | 20.8 | 19.3 | 18.4 | 13.6 | 11.8 | 11.2 | 12.0 | 11.7 |
| 29 | 8.0 | ..... | 10.9 | 17.4 | 20.8 | 19.3 | 18.2 | 13.4 | 11.7 | 11.7 | 11.9 | 11.8 |
| 30 | 8.0 | ..... | 11.3 | 17.5 | 20.8 | 19.5 | 18.0 | 13.2 | 11.7 | 11.4 | 11.9 | 11.6 |
| 31 | 8.0 | ..... | 11.2 | ..... | 21.0 | ..... | 17.9 | 13.0 | ..... | 11.1 | ..... | 11.6 |

## MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made on minor streams directly tributary to Columbia River during 1906:

*Miscellaneous measurements in Columbia River drainage basin in 1906.*

| Date. | Stream. | Locality. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|
| | | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| September 10 | Eightmile Creek | The Dalles, Oreg | | | | [a] 7 |
| April 26 | Sandy River | 3½ miles southeast of Troutdale, Oreg. | 202 | 1,320 | | 3,050 |
| July 27 | do | do | 180 | 774 | [b] 1.18 | 703 |
| August 31 [c] | do | Salmon River post-office, Oreg. | 88 | 154 | 1.15 | 397 |
| September 1 | do | Troutdale, Oreg | 178 | 750 | [b] 1.55 | 475 |
| September 30 | do | do | 183 | 844 | [d] 4.87 | 688 |
| September 27 | Still River | SW. ¼ sec. 13, T. 3 S., R. 7 E. | 20 | 22 | | 53 |
| August 31 | Salmon River | Salmon River post-office, Oreg. | 71 | 117 | | 120 |
| September 27 | Zigzag Creek | NE. ¼ sec. 17, T. 3 S., R. 7 E. | 22 | 14 | [e] 2.80 | 44 |
| September 1 | Bull Run Creek | Above Portland waterworks pipe intake. | 74 | 183 | | 93 |
| September 1 | do | do | 74 | 177 | | 110 |
| June 30 | Bull Run Creek pipe | Headworks | 14.5 | 52 | | 38 |
| September 1 | do | do | 14.5 | 46 | | 38 |

[a] Estimated.
[b] Below top portion of lower section of bridge caisson, right bank.
[c] Below junction of Salmon River.
[d] Below top of bridge caisson, left bank, downstream side.
[e] Below nail in alder on south bank 20 feet upstream from footbridge.

## CLARK FORK DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Clark Fork[a] rises on the eastern slopes of the high mountain ranges that form the boundary between Montana and Idaho. It flows northward, northwestward, and again northward as it crosses western Montana, northern Idaho (through Lake Pend Oreille), northeastern Washington, and a few miles into British Columbia, then turns somewhat abruptly westward and southwestward and joins the Columbia near Boundary station on the Spokane Falls and Northern Railroad.

To the river thus described various names have been applied in the past and are probably still used locally. The northward-flowing section above the town of Missoula has been known as the Bitterroot, the section between the junction of Hell Gate and Big Blackfoot rivers and Lake Pend Oreille has been called the Missoula, and the stretch of the river below its exit from Lake Pend Oreille has been called Pend Oreille River. These names, as well as Silver Bow, Hell Gate, and Deer Lodge, have been superseded, a recent decision of the Board on Geographic Names applying Clark Fork to the stream continuously from the head of the Bitterroot to the mouth of the Pend Oreille.

### CLARK FORK[b] NEAR GRANTSDALE, MONT.

This station was established April 25, 1902. It is located on the highway bridge 2 miles southwest of Grantsdale and 5 miles southwest of Hamilton, Mont. Length of chain in 1906, 23.25 feet. The bench mark is the northwest bolt in the northwest abutment of the bridge; elevation above gage datum, 19.36 feet. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 21, where are given also references to publications that contain data for previous years.

*Discharge measurements of Clark Fork near Grantsville, Mont., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 7 | Morse and Edson | 172 | 403 | 2.26 | 798 |
| April 27 | G. Edson | 186 | 567 | 3.27 | 1,970 |
| June 5 | do | 193 | 744 | 4.10 | 3,830 |
| July 7 | Morse and Richards | 183 | 486 | 2.95 | 1,460 |
| August 11[c] | R. Richards | 29 | 57 | 1.24 | 99 |
| September 9[c] | do | 37 | 56 | 1.24 | 114 |

[a] Clark Fork; river in Idaho, Montana, and Washington. (Not Bitter Root, Bitterroot, Clarke, Clarks River, Deer Lodge, Deerlodge, Hell Gate, Hellgate, Missoula, Silver Bow, nor Silverbow:) Third Report U. S. Board on Geographic Names, Washington, 1907, p. 51.

[b] Station formerly known as Bitterroot River near Grantsdale, Mont.

[c] Measured by wading.

*Daily gage height, in feet, of Clark Fork near Grantsdale, Mont., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.8 | 1.5 | 1.6 | 2.35 | 3.3 | 3.6 | 3.0 | 1.4 | 1.3 | 1.4 | 2.1 | 2.15 |
| 2 | 1.8 | 1.5 | 1.6 | 2.25 | 3.2 | 3.5 | 3.0 | 1.5 | 1.3 | 1.4 | 2.0 | 2.15 |
| 3 | 1.8 | 1.5 | 1.6 | 2.15 | 3.4 | 3.5 | 3.1 | 1.4 | 1.3 | 1.4 | 2.0 | 2.1 |
| 4 | 1.8 | 1.7 | 1.6 | 1.95 | 3.8 | 4.0 | 3.1 | 1.3 | 1.2 | 1.4 | 2.0 | 2.1 |
| 5 | 1.8 | 1.7 | 1.6 | 1.95 | 3.6 | 4.0 | 3.0 | 1.3 | 1.2 | 1.5 | 1.9 | 2.1 |
| 6 | 1.8 | 1.6 | 1.6 | 2.25 | 3.5 | 4.1 | 3.0 | 1.6 | 1.2 | 1.5 | 1.9 | 2.5 |
| 7 | 1.8 | 1.6 | 1.6 | 2.35 | 3.5 | 3.9 | 3.0 | 1.5 | 1.2 | 1.5 | 1.9 | 2.4 |
| 8 | 1.8 | 1.5 | 1.6 | 2.35 | 3.7 | 3.7 | 2.9 | 1.4 | 1.2 | 1.5 | 2.95 | 2.35 |
| 9 | 1.9 | 1.8 | 1.7 | 2.45 | 3.8 | 3.5 | 2.8 | 1.3 | 1.2 | 1.5 | 2.7 | 2.35 |
| 10 | 1.9 | 1.8 | 1.7 | 2.45 | 4.0 | 4.0 | 2.8 | 1.3 | 1.2 | 1.5 | 2.5 | 2.3 |
| 11 | 1.9 | 1.8 | 2.5 | 2.35 | 4.2 | 4.3 | 2.6 | 1.2 | 1.2 | 1.5 | 2.4 | 2.3 |
| 12 | 2.3 | 1.8 | 2.5 | 2.35 | 4.2 | 4.4 | 2.6 | 1.3 | 1.3 | 1.5 | 3.0 | 2.25 |
| 13 | 2.3 | 1.7 | 2.5 | 2.25 | 4.3 | 4.1 | 2.5 | 1.2 | 1.4 | 1.5 | 4.1 | 2.2 |
| 14 | 2.3 | 1.7 | 2.5 | 2.25 | 4.1 | 4.0 | 2.4 | 1.2 | 1.5 | 1.5 | 4.6 | 2.1 |
| 15 | 2.3 | 1.6 | 2.5 | 2.55 | 4.0 | 3.9 | 2.3 | 1.2 | 1.5 | 1.5 | 6.02 | 2.05 |
| 16 | 2.3 | 1.6 | 2.5 | 2.55 | 3.8 | 3.7 | 2.2 | 1.2 | 1.5 | 1.6 | 5.0 | 2.15 |
| 17 | 1.8 | 1.6 | 2.5 | 2.65 | 3.7 | 3.6 | 2.1 | 1.2 | 1.5 | 1.75 | 4.05 | 2.15 |
| 18 | 1.7 | 1.5 | 2.3 | 2.65 | 3.6 | 3.5 | 2.2 | 1.2 | 1.5 | 1.7 | 3.55 | 2.1 |
| 19 | 1.8 | 1.5 | 2.2 | 2.65 | 3.4 | 3.4 | 2.1 | 1.2 | 1.5 | 1.7 | 3.25 | 2.1 |
| 20 | 1.8 | 1.6 | 2.0 | 2.75 | 3.3 | 3.3 | 2.0 | 1.1 | 1.6 | 1.7 | 3.0 | 2.1 |
| 21 | 1.8 | 1.6 | 1.8 | 3.05 | 3.5 | 3.2 | 1.9 | 1.1 | 1.6 | 1.65 | 2.7 | 2.2 |
| 22 | 1.7 | 1.6 | 1.8 | 3.45 | 3.4 | 3.1 | 1.9 | 1.3 | 1.6 | 1.6 | 2.6 | 2.25 |
| 23 | 1.7 | 1.6 | 1.8 | 3.85 | 3.4 | 3.0 | 1.9 | 1.4 | 1.6 | 1.65 | 2.5 | 2.25 |
| 24 | 1.7 | 1.6 | 1.7 | 4.15 | 3.5 | 3.0 | 1.8 | 1.4 | 1.5 | 1.65 | 2.35 | 2.2 |
| 25 | 1.6 | 1.6 | 2.1 | 3.85 | 4.0 | 3.1 | 1.7 | 1.5 | 1.5 | 1.7 | 2.3 | 2.2 |
| 26 | 1.6 | 1.6 | 2.0 | 3.45 | 4.3 | 3.2 | 1.7 | 1.5 | 1.5 | 1.9 | 2.3 | 2.25 |
| 27 | 1.6 | 1.6 | 2.0 | 3.25 | 4.4 | 3.3 | 1.5 | 1.5 | 1.5 | 2.9 | 2.25 | 2.3 |
| 28 | 1.6 | 1.6 | 2.0 | 3.2 | 4.3 | 3.8 | 1.5 | 1.4 | 1.4 | 2.7 | 2.25 | 2.3 |
| 29 | 1.6 | ..... | 2.0 | 3.3 | 4.0 | 3.5 | 1.3 | 1.4 | 1.4 | 2.5 | 2.2 | 2.25 |
| 30 | 1.5 | ..... | 2.0 | 3.3 | 3.9 | 3.4 | 1.4 | 1.3 | 1.4 | 2.4 | 2.15 | 2.35 |
| 31 | 1.5 | ..... | 2.2 | ..... | 3.8 | ..... | 1.3 | 1.3 | ..... | 2.2 | ..... | 2.4 |

NOTE.—Ice conditions January 12 to 17 and February 9 to March 21.

*Rating table for Clark Fork near Grantsdale, Mont., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.10 | 60 | 1.80 | 395 | 2.50 | 1,020 | 3.20 | 1,825 | 3.90 | 3,005 |
| 1.20 | 80 | 1.90 | 470 | 2.60 | 1,120 | 3.30 | 1,965 | 4.00 | 3,215 |
| 1.30 | 110 | 2.00 | 550 | 2.70 | 1,225 | 3.40 | 2,105 | 4.20 | 3,660 |
| 1.40 | 150 | 2.10 | 635 | 2.80 | 1,335 | 3.50 | 2,265 | 4.40 | 4,110 |
| 1.50 | 200 | 2.20 | 725 | 2.90 | 1,450 | 3.60 | 2,435 | | |
| 1.60 | 260 | 2.30 | 820 | 3.00 | 1,570 | 3.70 | 2,615 | | |
| 1.70 | 325 | 2.40 | 920 | 3.10 | 1,695 | 3.80 | 2,805 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 17 discharge measurements made during 1904–1906 and is well defined.

*Monthly discharge of Clark Fork near Grantsdale, Mont., for 1906.*

[Drainage area, 1,550 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January [a] | 470 | 200 | 359 | 22,100 | 0.232 | 0.27 |
| February 1–8 | 325 | 200 | 246 | 3,900 | .159 | .05 |
| March 22–31 | 725 | 325 | 522 | 10,400 | .337 | .13 |
| April | 3,550 | 510 | 1,370 | 81,500 | .884 | .99 |
| May | 4,110 | 1,825 | 2,800 | 172,000 | 1.81 | 2.09 |
| June | 4,110 | 1,570 | 2,540 | 151,000 | 1.64 | 1.83 |
| July | 1,700 | 110 | 866 | 53,200 | .559 | .64 |
| August | 260 | 60 | 127 | 7,810 | .082 | .09 |
| September | 260 | 80 | 157 | 9,340 | .101 | .11 |
| October | 1,450 | 150 | 386 | 23,700 | .249 | .29 |
| November | 8,100 | 470 | 1,650 | 98,200 | 1.06 | 1.18 |
| December | 1,020 | 592 | 750 | 46,100 | .484 | .56 |
| The period | ..... | ..... | ..... | 679,000 | ..... | ..... |

[a] Discharge estimated January 12 to 17.

NOTE.—Values are rated as follows: January to March and August to October, good; remainder of the period, excellent.

## CLARK FORK [a] AT MISSOULA, MONT.

This station was established July 10, 1898, at Higgins Avenue Bridge, Missoula, Mont., but was removed May 27, 1899, to the bridge of the Bitterroot Valley division of the Northern Pacific Railway, about one-half mile downstream. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 16, where are given also references to publications that contain data for previous years.

*Discharge measurements of Clark Fork at Missoula, Mont., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 6 | Morse and Edson | 195 | 833 | 3.43 | 1,750 |
| April 6 | do | 195 | 813 | 3.45 | 1,650 |
| April 26 | G. Edson | 275 | 1,250 | 4.90 | 4,230 |
| June 6 | do | 306 | 1,480 | 6.08 | 7,370 |
| July 6 | Morse and Richards | 172 | 912 | 4.13 | 2,690 |
| August 10 | R. Richards | 162 | 715 | 3.08 | 1,070 |
| September 8 | do | 137 | 699 | 2.77 | 1,050 |
| September 19 | Grover and Follansbee | 162 | 733 | 3.07 | 1,050 |
| October 15 | Richards and Follansbee | 162 | 723 | 2.93 | 972 |

*Daily gage height, in feet, of Clark Fork at Missoula, Mont., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.10 | 3.30 | 2.80 | 4.12 | 4.52 | 5.70 | 4.70 | 3.08 | 3.05 | 2.85 | 3.25 | 3.60 |
| 2 | 3.10 | 3.30 | 2.68 | 4.18 | 4.50 | 5.60 | 4.62 | 3.02 | 3.00 | 2.90 | 3.20 | 3.60 |
| 3 | 3.10 | 3.35 | 2.60 | 3.78 | 4.58 | 5.65 | 4.62 | 3.00 | 3.00 | 2.90 | 3.20 | 3.60 |
| 4 | 3.10 | 3.35 | 2.65 | 3.50 | 4.80 | 5.72 | 4.48 | 3.00 | 3.00 | 2.85 | 3.25 | 3.62 |
| 5 | 3.10 | 3.35 | 2.70 | 3.42 | 4.85 | 5.95 | 4.32 | 3.00 | 2.98 | 2.90 | 3.20 | 3.78 |
| 6 | 3.10 | 3.35 | 2.80 | 3.45 | 4.80 | 6.02 | 4.25 | 3.00 | 2.90 | 2.90 | 3.20 | 3.70 |
| 7 | 3.10 | 3.35 | 2.90 | 3.60 | 4.65 | 6.12 | 4.10 | 3.00 | 2.85 | 2.90 | 3.22 | 3.72 |
| 8 | 3.10 | 3.35 | 2.95 | 3.70 | 4.62 | 5.95 | 4.00 | 3.10 | 2.78 | 2.90 | 3.45 | 3.75 |
| 9 | 3.12 | 3.35 | 2.95 | 3.75 | 4.75 | 5.80 | 3.98 | 3.15 | 2.78 | 2.85 | 3.60 | 3.70 |
| 10 | 3.15 | 3.35 | 2.95 | 3.72 | 4.80 | 5.72 | 3.95 | 3.15 | 2.75 | 2.85 | 3.60 | 3.65 |
| 11 | 3.15 | 3.35 | 2.95 | 3.68 | 5.00 | 5.72 | 3.88 | 2.95 | 2.85 | 2.90 | 3.65 | 3.68 |
| 12 | 3.20 | 3.35 | 2.95 | 3.62 | 5.25 | 5.72 | 3.80 | 2.95 | 2.85 | 2.90 | 3.60 | 3.75 |
| 13 | 3.20 | 3.35 | 2.95 | 3.58 | 5.38 | 5.78 | 3.72 | 3.00 | 2.85 | 2.95 | 3.68 | 3.80 |
| 14 | 3.20 | 3.35 | 2.95 | 3.52 | 5.40 | 5.78 | 3.60 | 3.05 | 2.90 | 2.95 | 4.20 | 3.68 |
| 15 | 3.20 | 3.35 | 2.95 | 3.52 | 5.30 | 5.62 | 3.65 | 3.00 | 3.18 | 2.95 | 5.00 | 3.48 |
| 16 | 3.20 | 3.35 | 2.95 | 3.60 | 5.30 | 5.48 | 3.70 | 3.00 | 3.32 | 2.95 | 5.18 | 3.45 |
| 17 | 3.20 | 3.35 | 3.15 | 3.72 | 5.15 | 5.60 | 3.62 | 2.92 | 3.22 | 3.05 | 5.15 | 3.48 |
| 18 | 3.20 | 3.35 | 3.25 | 3.80 | 5.00 | 5.50 | 3.58 | 2.82 | 3.08 | 3.08 | 4.70 | 3.58 |
| 19 | 3.25 | 3.35 | 3.25 | 3.88 | 4.85 | 5.28 | 3.50 | 2.82 | 3.10 | 3.10 | 4.48 | 3.70 |
| 20 | 3.25 | 3.35 | 3.40 | 3.90 | 4.80 | 5.10 | 3.45 | 2.80 | 3.05 | 3.15 | 4.28 | 3.68 |
| 21 | 3.10 | 3.35 | 3.40 | 4.00 | 4.80 | 5.02 | 3.40 | 2.78 | 3.08 | 3.10 | 4.35 | 3.65 |
| 22 | 3.30 | 2.90 | 3.30 | 4.25 | 4.88 | 4.98 | 3.40 | 2.75 | 3.05 | 3.05 | 4.22 | 3.60 |
| 23 | 3.30 | 2.80 | 3.30 | 4.55 | 4.90 | 4.90 | 3.35 | 3.10 | 3.00 | 3.05 | 4.15 | 3.60 |
| 24 | 3.30 | 2.70 | 3.98 | 4.90 | 4.90 | 4.80 | 3.30 | 3.25 | 2.98 | 3.05 | 4.02 | 3.60 |
| 25 | 3.30 | 2.60 | 3.95 | 5.00 | 4.98 | 4.78 | 3.22 | 3.28 | 2.92 | 3.05 | 4.00 | 3.65 |
| 26 | 3.30 | 2.80 | 4.35 | 4.88 | 4.98 | 4.70 | 3.20 | 3.35 | 2.95 | 3.22 | 3.98 | 3.75 |
| 27 | 3.30 | 2.80 | 4.25 | 4.80 | 5.10 | 4.60 | 3.12 | 3.30 | 2.95 | 3.30 | 3.70 | 3.80 |
| 28 | 3.30 | 2.80 | 3.95 | 4.75 | 5.30 | 4.70 | 3.10 | 3.22 | 2.95 | 3.25 | 3.60 | 3.80 |
| 29 | 3.30 | ..... | 3.90 | 4.70 | 5.55 | 4.80 | 3.10 | 3.15 | 2.90 | 3.25 | 3.70 | 3.75 |
| 30 | 3.30 | ..... | 3.85 | 4.62 | 5.78 | 4.78 | 3.10 | 3.10 | 2.90 | 3.25 | 3.60 | 3.70 |
| 31 | 3.30 | ..... | 3.92 | ..... | 5.75 | ..... | 3.10 | 3.08 | ..... | 3.25 | ..... | 3.60 |

NOTE.—Ice conditions January 2 to February 19 and March 10 to 24. There was no ice during December.

[a] Station formerly known as Missoula River at Missoula, Mont.

*Rating table for Clark Fork at Missoula, Mont., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.50 | 750 | 3.30 | 1,440 | 4.10 | 2,610 | 4.90 | 4,230 | 5.60 | 5,990 |
| 2.60 | 810 | 3.40 | 1,560 | 4.20 | 2,790 | 5.00 | 4,460 | 5.70 | 6,270 |
| 2.70 | 880 | 3.50 | 1,690 | 4.30 | 2,970 | 5.10 | 4,700 | 5.80 | 6,550 |
| 2.80 | 950 | 3.60 | 1,830 | 4.40 | 3,160 | 5.20 | 4,950 | 5.90 | 6,840 |
| 2.90 | 1,030 | 3.70 | 1,970 | 4.50 | 3,360 | 5.30 | 5,200 | 6.00 | 7,130 |
| 3.00 | 1,120 | 3.80 | 2,120 | 4.60 | 3,570 | 5.40 | 5,460 | 6.20 | 7,740 |
| 3.10 | 1,220 | 3.90 | 2,280 | 4.70 | 3,780 | 5.50 | 5,720 | 6.40 | 8,370 |
| 3.20 | 1,330 | 4.00 | 2,440 | 4.80 | 4,000 | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 9 discharge measurements made during 1906 and is well defined between gage heights 3.5 feet and 6.0 feet. Below gage height 3.5 feet the table is only fair.

*Monthly discharge of Clark Fork at Missoula, Mont., for 1906.*

[Drainage area, 5,960 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| February 20–28 | 1,500 | 810 | 1,060 | 18,900 | 0.178 | 0.06 |
| March [a] | 3,060 | 810 | 1,480 | 91,000 | .248 | .29 |
| April | 4,460 | 1,590 | 2,560 | 152,000 | .430 | .48 |
| May | 6,490 | 3,360 | 4,510 | 277,000 | .757 | .87 |
| June | 7,490 | 3,570 | 5,510 | 328,000 | .924 | 1.03 |
| July | 3,780 | 1,220 | 2,060 | 127,000 | .346 | .40 |
| August | 1,500 | 915 | 1,170 | 71,900 | .196 | .23 |
| September | 1,460 | 915 | 1,100 | 65,500 | .185 | .21 |
| October | 1,440 | 990 | 1,150 | 70,700 | .193 | .22 |
| November | 4,900 | 1,330 | 2,360 | 140,000 | .396 | .44 |
| December | 2,120 | 1,620 | 1,920 | 118,000 | .322 | .37 |
| The period | | | | 1,460,000 | | |

[a] Open channel rating applied March 10 to 24.

NOTE.—Values are rated as follows: February, March, and August to December, fair; April to July, good.

## STILLWATER RIVER NEAR KALISPELL, MONT.

Stillwater River rises in the northern part of Flathead County and flows southeast through several lakes into Flathead River.

The gaging station was established September 25, 1906. The gage is located at the Reiter wagon bridge, 2 miles from Kalispell. The flow is controlled by dams above. The measuring section is below the mouth of Whitefish River and includes the flow of that stream. The intake for the city waterworks is between the mouth of Whitefish and the gage. Owing to the extreme sluggishness of the Stillwater above the mouth of the Whitefish, it is impossible to make measurements; hence the flow of the former is obtained by subtracting the flow at the Whitefish station from that at this station. This gives the amount available for irrigation.

Discharge measurements are made from the bridge or may be made by wading at low stage.

The gage, which is read morning and evening by W. H. Reiter, is a staff, fastened to the upstream end of the bridge pier. The bench

mark is a spike in the piling which is the upstream edge of the pier on which the right end of the right truss rests; it is 3 feet above the ground and is driven horizontally; elevation, 4.74 feet above gage datum.

*Discharge measurements of Stillwater River near Kalispell, Mont., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| September 25 | Follansbee and Wade | 90 | 305 | 1.64 | 142 |
| October 2 | Follansbee and Richards | 98 | 309 | 1.52 | 125 |
| November 22[a] | R. Richards | 67 | 107 | 2.12 | 322 |

[a] Measured by wading.

*Daily gage height, in feet, of Stillwater River near Kalispell, Mont., for 1906.*

| Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1.95 | 1.50 | 2.58 | 12 | | 1.95 | 1.70 | 1.70 | 23 | | 1.85 | 1.75 | 2.10 |
| 2 | | 1.80 | 2.02 | 2.50 | 13 | | 1.41 | 1.75 | 1.95 | 24 | | 1.82 | 1.65 | 1.80 |
| 3 | | 2.10 | 2.20 | 2.50 | 14 | | 1.21 | 1.85 | 2.32 | 25 | 1.65 | 1.35 | 2.30 | 1.68 |
| 4 | | 1.85 | 1.45 | 2.42 | 15 | | 1.71 | 2.05 | 2.28 | 26 | 1.60 | 1.92 | 2.75 | 2.05 |
| 5 | | 1.70 | 2.00 | 2.45 | 16 | | 1.70 | 3.25 | 2.28 | 27 | 1.72 | 2.22 | 2.70 | 1.55 |
| 6 | | 1.68 | 2.05 | 2.40 | 17 | | 1.56 | 3.05 | 2.28 | 28 | 1.95 | 2.15 | 2.65 | 1.95 |
| 7 | | 1.56 | 1.70 | 1.98 | 18 | | 1.56 | 2.95 | 2.30 | 29 | 2.32 | 1.95 | 2.62 | 1.70 |
| 8 | | 1.31 | 1.60 | 1.75 | 19 | | 1.60 | 2.32 | 2.25 | 30 | 2.40 | 1.38 | 2.58 | 1.70 |
| 9 | | 1.90 | 1.35 | 1.72 | 20 | | 1.51 | 2.02 | 2.25 | 31 | | 1.98 | | 1.58 |
| 10 | | 1.86 | 2.00 | 1.70 | 21 | | 1.28 | 2.00 | 2.20 | | | | | |
| 11 | | 1.60 | 1.90 | 1.70 | 22 | | 1.15 | 2.00 | 2.20 | | | | | |

NOTE.—The flow of this stream is controlled by dams.

*Rating table for Stillwater River near Kalispell, Mont., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.10 | 67 | 1.60 | 140 | 2.10 | 310 | 2.60 | 670 | 3.10 | 1,200 |
| 1.20 | 77 | 1.70 | 163 | 2.20 | 370 | 2.70 | 760 | 3.20 | 1,320 |
| 1.30 | 89 | 1.80 | 190 | 2.30 | 430 | 2.80 | 860 | 3.30 | 1,450 |
| 1.40 | 104 | 1.90 | 220 | 2.40 | 500 | 2.90 | 970 | | |
| 1.50 | 120 | 2.00 | 260 | 2.50 | 580 | 3.00 | 1,080 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 3 discharge measurements made during 1906.

*Monthly discharge of Stillwater River near Kalispell, Mont., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| September 25–30 | 500 | 140 | 274 | 3,260 |
| October | 382 | 72 | 178 | 10,900 |
| November | 1,380 | 95 | 410 | 24,400 |
| December | 658 | 136 | 327 | 20,100 |
| The period | | | | 58,660 |

NOTE.—Values are rated as follows: September, October, and December, good; November, fair.

### WHITEFISH RIVER NEAR KALISPELL, MONT.

Whitefish River rises in the central part of Flathead County and flows south into Stillwater River above the gaging station on that stream.

The gaging station was established September 24, 1906. It is located at the Tetrault wagon bridge 10 miles from Kalispell and 6 miles from Columbia Falls. There is a dam at the outlet of the lake which feeds the river, and consequently the flow is wholly controlled.

The channel is straight for 500 feet above, and 200 feet below the station. The banks are high and are not likely to overflow. The bed of the stream is composed of gravel and is permanent. There is one channel at all stages.

Discharge measurements are made from the wagon bridge or may be made by wading at low stage.

The gage, which is read daily by F. R. Miles, is a staff fastened to timber abutment 200 feet upstream from the bridge, on the left bank. The bench mark is a black paint spot on a bowlder on the right bank, near the water's edge and directly downstream from old timber abutment; it is marked "U. S. G. S. B. M."; elevation, 3.02 feet above the gage datum.

*Discharge measurements of Whitefish River near Kalispell, Mont., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| September 24[a] | Wade and Follansbee | 106 | 99.7 | 2.28 | 126 |
| October 22[b] | Follansbee and Richards | 26 | 19.1 | 1.35 | 14.8 |
| November 22[b] | R. Richards | 32 | 25.0 | 1.70 | 15.9 |

[a] Made at bridge. [b] Made by wading.

*Daily gage height, in feet, of Whitefish River near Kalispell, Mont., for 1906.*

| Day. | Nov. | Dec. | Day. | Nov. | Dec. | Day. | Nov. | Dec. | Day. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 2.95 | 8 | | 1.6 | 17 | 2.0 | | 24 | 2.5 | |
| 2 | | 2.95 | 11 | 1.4 | | 18 | 2.0 | | 25 | 2.6 | |
| 3 | | 2.9 | 12 | 1.4 | | 19 | 2.2 | | 26 | 2.6 | |
| 4 | | 2.85 | 13 | 1.4 | | 20 | 2.3 | | 27 | 2.8 | |
| 5 | | 2.8 | 14 | 1.4 | | 21 | 2.4 | | 28 | 3.0 | |
| 6 | | 2.65 | 15 | 1.6 | | 22 | 2.4 | | 29 | 3.0 | |
| 7 | | 1.65 | 16 | 1.9 | | 23 | 2.4 | | 30 | 3.0 | |

### CROW CREEK NEAR RONAN, MONT.

Crow Creek rises on the western slope of the Mission Range and flows westward across the Flathead Reservation, emptying into Clark Fork.

The gaging station was established September 21, 1906. It is located at the highway bridge on the stage road from St. Ignatius

to Ronan, 4 miles south of Ronan. The station is several miles below the canyon.

The channel curves sharply to the right immediately above the station, but is straight for 200 feet below. The banks slope back gradually from the water's edge. At all stages except extreme flood the water will all pass beneath the bridge. The current is sluggish. The bed of the stream is composed of fine gravel.

Discharge measurements are made by wading at a section either above or below the bridge. At high stages measurements may be made at the bridge.

The gage, which is read morning and evening by Mrs. Alphonsine McIntyre, is a staff fastened to the upstream end of the bridge pier. The bench mark is a spike driven horizontally 2 feet above the ground, in the northeast corner of a log building, 50 feet downstream from the gage, on the left bank; elevation, 10 feet above the datum of the gage.

*Discharge measurements of Crow Creek near Ronan, Mont., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| September 20[a]. | Wade and Follansbee | 33 | 56.5 | 1.00 | 24.9 |
| October 18[b]. | Follansbee and Richards | 28 | 28.9 | 1.15 | 35.7 |
| November 19[b]. | R. Richards | 28 | 39.0 | 1.86 | 73.8 |

[a] Made at bridge. [b] Made by wading.

*Daily gage height, in feet, of Crow Creek River near Ronan, Mont., for 1906.*

| Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0.9 | 1.0 | 1.25 | 12 | | 1.0 | 1.3 | 1.0 | 22 | 1.0 | 1.0 | 1.5 | 1.1 |
| 2 | | .9 | 1.0 | 1.2 | 13 | | 1.05 | 1.6 | 1.0 | 23 | .95 | 1.0 | 1.45 | 1.05 |
| 3 | | 1.2 | 1.0 | 1.15 | 14 | | 1.0 | 1.8 | 1.05 | 24 | .9 | 1.0 | 1.4 | |
| 4 | | 1.15 | 1.0 | 1.15 | 15 | | 1.0 | 2.2 | 1.15 | 25 | .9 | 1.0 | 1.4 | |
| 5 | | 1.0 | 1.0 | 1.15 | 16 | | 1.1 | 2.95 | 1.05 | 26 | .9 | 1.15 | 1.25 | 1.6 |
| 6 | | 1.0 | 1.0 | 1.1 | 17 | | 1.15 | 2.2 | 1.0 | 27 | .9 | 1.3 | 1.1 | 1.4 |
| 7 | | 1.0 | 1.0 | 1.05 | 18 | | 1.2 | 2.0 | 1.0 | 28 | 1.0 | 1.2 | 1.2 | 1.35 |
| 8 | | 1.0 | 1.3 | 1.1 | 19 | | 1.1 | 1.9 | 1.0 | 29 | .95 | 1.2 | 1.2 | 1.3 |
| 9 | | 1.0 | 1.3 | 1.1 | 20 | | 1.05 | 1.8 | 1.0 | 30 | .9 | 1.1 | 1.2 | 1.3 |
| 10 | | 1.0 | 1.3 | 1.0 | 21 | 1.0 | 1.0 | 1.6 | 1.0 | 31 | | 1.1 | | 1.2 |
| 11 | | 1.0 | 1.3 | 1.0 | | | | | | | | | | |

*Rating table for Crow Creek near Ronan, Mont., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.90 | 22 | 1.40 | 48 | 1.80 | 71 | 2.20 | 96 | 2.60 | 126 |
| 1.00 | 27 | 1.50 | 53 | 1.90 | 76 | 2.30 | 103 | 2.70 | 134 |
| 1.10 | 32 | 1.60 | 59 | 2.00 | 82 | 2.40 | 110 | 2.80 | 143 |
| 1.20 | 37 | 1.70 | 65 | 2.10 | 89 | 2.50 | 118 | 2.90 | 152 |
| 1.30 | 42 | | | | | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 3 discharge measurements made during 1906 and is not well defined.

*Monthly discharge of Crow Creek near Ronan, Mont., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| September 21–30 | 27 | 22 | 23.9 | 474 |
| October | 42 | 22 | 29.9 | 1,840 |
| November | 156 | 27 | 51.5 | 3,060 |
| December | 59 | 27 | 34.2 | 2,100 |
| The period | | | | 7,470 |

NOTE.—Values are only approximate on account of the small number of measurements.

## MISSION CREEK NEAR ST. IGNATIUS, MONT.

Mission Creek rises on the western slope of the Mission Range and flows across the Flathead Reservation into Clark Fork.

The station was established September 21, 1906. It is located opposite the home of A. A. Booke, 1 mile downstream from St. Ignatius. There are a few small ditches diverting water above the gage.

The channel curves both above and below the station. The right bank is low and liable to overflow; the left is high and will not overflow. The current is swift. The bed is composed of gravel and is permanent. There is one channel at all stages.

Discharge measurements are made from the footbridge to which the staff gage is attached. The gage, which is 6 or 8 miles below the canyon, is read morning and evening by Mrs. A. A. Booke. The bench mark is a large spike driven horizontally in a pine tree 27 feet back of the gage on the left bank, below a blaze in the tree and 1 foot above the ground; elevation, 7.05 feet above the gage datum.

*Discharge measurements of Mission Creek near St. Ignatius, Mont., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| September 21 | Wade and Follansbee | 30 | 25.8 | 0.78 | 65.4 |
| October 17 | Follansbee and Richards | 29 | 25.9 | .76 | 56.5 |
| November 19 | R. Richards | 28 | 21.5 | .66 | 46.5 |

*Daily gage height, in feet, of Mission Creek near St. Ignatius, Mont., for 1906.*

| Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0.7 | 0.7 | 0.5 | 12 | | 0.7 | 0.65 | 0.55 | 23 | 0.75 | 0.65 | 0.65 | 0.55 |
| 2 | | .7 | .7 | .55 | 13 | | .7 | .7 | .55 | 24 | .75 | .65 | .6 | .55 |
| 3 | | .7 | .7 | .55 | 14 | | .7 | .75 | .55 | 25 | .7 | .65 | .6 | .6 |
| 4 | | .7 | .7 | .55 | 15 | | .7 | .82 | .55 | 26 | .7 | .68 | .6 | .6 |
| 5 | | .7 | .7 | .55 | 16 | | .7 | .82 | .55 | 27 | .7 | .72 | .6 | .6 |
| 6 | | .7 | .68 | .55 | 17 | | .72 | .72 | .55 | 28 | .7 | .75 | .58 | .6 |
| 7 | | .7 | .75 | .55 | 18 | | .72 | .7 | .55 | 29 | .7 | .75 | .55 | .6 |
| 8 | | .7 | .7 | .55 | 19 | | .72 | .65 | .55 | 30 | .7 | .7 | .52 | .55 |
| 9 | | .75 | .7 | .55 | 20 | | .7 | .7 | .55 | 31 | | .7 | | .55 |
| 10 | | .7 | .65 | .55 | 21 | 0.8 | .7 | .65 | .55 | | | | | |
| 11 | | .7 | .65 | .55 | 22 | .8 | .7 | .65 | .55 | | | | | |

*Rating table for Mission Creek near St. Ignatius, Mont., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.50 | 33 | 0.60 | 40 | 0.70 | 50 | 0.80 | 65 | 0.90 | 85 |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 3 discharge measurements made during 1906 and is not well defined.

*Monthly discharge of Mission Creek near St. Ignatius, Mont., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| September 21–30 | 65 | 50 | 54.4 | 1,080 |
| October | 57 | 45 | 50.5 | 3,110 |
| November | 69 | 34 | 48.1 | 2,860 |
| December | 40 | 33 | 36.5 | 2,240 |
| The period | | | | 9,290 |

NOTE.—Values are only fair on account of the small number of measurements.

## POST CREEK NEAR ST. IGNATIUS, MONT.

Post Creek rises on the western slope of the Mission Range and flows across Flathead Reservation into Mission Creek, a tributary of Clark Fork.

The gaging station was established September 21, 1906. It is located at the upper highway bridge, near the home of Joseph Allard, 10 miles north of St. Ignatius. The station is near the canyon and only two small ditches divert above. Because of the storage possibilities of McDonald Lake, the source of Post Creek, and also because of the land which can be reached, this station is very important.

The channel is straight for 25 feet above and 100 feet below the gage. The current is very swift. Both banks are wooded and will not overflow. The bed of the stream is composed of gravel and small bowlders and is permanent. There is one channel at all stages.

Discharge measurements are made from the downstream side of the highway bridge.

The gage, which is read twice each day by Mrs. Adaline Allard, is a staff fastened to the overhanging stump at the right end of the bridge. The bench mark is a headless spike, 2 feet above the ground, in a blaze in a pine tree 2 feet in diameter, 45 feet from the left bank and 18 feet from the road; elevation, 8.90 feet above the gage datum.

*Discharge measurements of Post Creek near St. Ignatius, Mont., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| September 21 | Grover and Follansbee | 22 | 24.0 | 1.50 | 63.2 |
| October 17 | Follansbee and Richards | 22 | 23.4 | 1.51 | 58.8 |
| November 19 | R. Richards | 25 | 29.6 | 1.73 | 70.7 |

*Daily gage height, in feet, of Post Creek near St. Ignatius, Mont., for 1906.*

| Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. | Day. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1.4 | 1.5 | 1.4 | 12 | | 1.5 | 1.8 | 1.3 | 22 | 1.5 | 1.4 | 1.7 | 1.3 |
| 2 | | 1.4 | 1.4 | 1.4 | 13 | | 1.4 | 1.8 | 1.3 | 23 | 1.4 | 1.4 | 1.65 | 1.3 |
| 3 | | 1.3 | 1.4 | 1.3 | 14 | | a1.4 | 1.9 | 1.3 | 24 | 1.5 | 1.4 | 1.55 | 1.3 |
| 4 | | 1.4 | 1.4 | 1.3 | 15 | | a1.4 | 2.0 | 1.3 | 25 | 1.5 | 1.4 | 1.5 | 1.3 |
| 5 | | 1.5 | 1.5 | 1.3 | 16 | | a1.5 | 2.0 | 1.3 | 26 | a1.5 | 1.4 | 1.5 | 1.3 |
| 6 | | 1.4 | 1.5 | 1.3 | 17 | | 1.5 | 1.9 | 1.3 | 27 | 1.5 | 1.4 | 1.45 | 1.3 |
| 7 | | 1.4 | 1.5 | 1.3 | 18 | | 1.5 | 1.8 | 1.3 | 28 | 1.4 | 1.4 | 1.4 | 1.3 |
| 8 | | 1.4 | 1.6 | 1.3 | 19 | | 1.6 | 1.7 | 1.3 | 29 | 1.4 | 1.4 | 1.4 | 1.3 |
| 9 | | 1.4 | 1.6 | 1.3 | 20 | | 1.5 | 1.7 | 1.3 | 30 | 1.4 | 1.5 | 1.4 | 1.3 |
| 10 | | 1.4 | 1.7 | 1.3 | 21 | 1.5 | 1.4 | 1.7 | 1.3 | 31 | | 1.5 | | 1.3 |
| 11 | | 1.4 | 1.7 | 1.3 | | | | | | | | | | |

a Interpolated.

*Rating table for Post Creek near St. Ignatius, Mont., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.30 | 50 | 1.50 | 59 | 1.70 | 69 | 1.90 | 81 | 2.00 | 88 |
| 1.40 | 54 | 1.60 | 64 | 1.80 | 75 | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 3 discharge measurements made during 1906 and is not well defined.

*Monthly discharge of Post Creek near St. Ignatius, Mont., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| September 21–30 | 59 | 54 | 57.0 | 1,130 |
| October | 64 | 50 | 55.5 | 3,410 |
| November | 88 | 54 | 65.5 | 3,900 |
| December | 54 | 50 | 50.3 | 3,090 |
| The period | | | | 11,530 |

NOTE.—Values are only fair on account of the small number of measurements.

## JOCKO RIVER AT RAVALLI, MONT.

Jocko River rises in the southeastern part of Flathead Reservation and flows northwest into Clark Fork.

The gaging station, which was established October 18, 1906, is located 400 feet downstream from a point opposite the railroad station at Ravalli.

The channel is straight for several hundred feet above and below the gage. Both banks are sparsely wooded and will not overflow except at very high stage. The current is swift, and small rapids occur a short distance below the gage. The bed of the stream is composed of gravel and small bowlders and is permanent. There is one channel at all stages.

Discharge measurements may be made from the highway bridge 1 mile upstream, or preferably by wading at or near the gage. In high water the bridge must be used.

The gage, which is read daily by H. F. Lynn, the station agent, is a staff fastened to an overhanging tree on the right bank. The bench mark is a nail 2 feet above the ground in a tree 25 feet northeast of the gage; elevation, 6.80 feet above the datum of the gage.

*Discharge measurements of Jocko River at Ravalli, Mont., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| October 18[a] | Follansbee and Richards | 46 | 80 | 1.69 | 150 |
| November 20[b] | R. Richards | 67 | 120 | 2.14 | 317 |

[a] Measured at bridge. [b] Measured by wading at gage.

*Daily gage height, in feet, of Jocko River at Ravalli, Mont., for 1906.*

| Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 1.75 | ..... | 12 | ..... | 1.8 | 1.85 | 22 | 1.65 | 1.85 | 1.8 |
| 2 | ..... | 1.75 | 1.8 | 13 | ..... | 2.1 | 1.8 | 23 | 1.65 | 1.85 | 1.8 |
| 3 | ..... | 1.7 | 1.8 | 14 | ..... | 2.15 | 1.8 | 24 | 1.65 | 1.85 | 1.8 |
| 4 | ..... | 1.7 | 1.8 | 15 | ..... | 2.75 | 1.8 | 25 | 1.65 | 1.85 | 1.8 |
| 5 | ..... | 1.7 | 1.8 | 16 | ..... | 2.7 | 1.8 | 26 | 2.0 | 1.85 | 1.85 |
| 6 | ..... | 1.7 | 1.8 | 17 | ..... | 2.5 | 1.8 | 27 | 2.1 | 1.8 | 1.9 |
| 7 | ..... | 1.7 | 1.85 | 18 | 1.65 | 2.3 | 1.8 | 28 | 1.95 | 1.8 | 1.9 |
| 8 | ..... | 1.85 | 1.8 | 19 | 1.65 | 2.1 | 1.75 | 29 | 1.9 | 1.8 | 1.85 |
| 9 | ..... | 1.8 | 1.8 | 20 | 1.65 | 1.95 | 1.8 | 30 | 1.8 | 1.8 | ..... |
| 10 | ..... | 1.8 | 1.8 | 21 | 1.65 | 1.9 | 1.8 | 31 | 1.8 | ..... | ..... |
| 11 | ..... | 1.8 | 1.85 | | | | | | | | |

### MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in Clark Fork drainage basin in 1906:

*Miscellaneous measurements in Clark Fork drainage basin.*

| Date. | Stream. | Locality. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|
| | | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| September 20 | Mud Creek | Highway bridge near Ronan, Mont. | 8 | 4.5 | 1.51 | 2.55 |
| September 25 | South Fork of Flathead River. | Columbia Falls, Mont | 195 | 312 | ..... | 649 |

## SPOKANE RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Spokane River has its source in Lake Coeur d'Alene, Idaho, flows westward through Washington for about 120 miles, and empties into Columbia River. Its drainage area consists of rough mountainous land, more or less timbered, interspersed here and there with valleys or level table-lands of tillable areas.

The rainfall in this basin is approximately 20 inches per annum, and the region is semiarid. The principal tributary streams are Hangman Creek, Little Spokane, and Chamokane rivers.

The waters of the streams are largely used for irrigation, power, and municipal water supply. The city of Spokane is furnished with an abundance of electric power from plants at Spokane, Wash., and Post Falls, Idaho. The waters of Little Spokane River are in great demand for irrigation development.

### SPOKANE RIVER AT SPOKANE, WASH.

This gaging station was originally established October 17, 1896, on the Oregon Railroad and Navigation Company's wooden bridge, about 1 mile above the falls, where discharge measurements and gage readings were taken until July 8, 1903, the gage datum being 1,880 feet above sea level by city datum and 1,865 feet by Government datum.

March 30, 1904, a cable station was established about one-half mile above the Mission Street Bridge, or 1 mile above the former station at the Oregon Railroad and Navigation Company's bridge. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 25, where are given also references to publications that contain data for previous years.

The following measurement was made October 1, 1906:

Width, 195 feet; area, 1,630 square feet; gage height, 1.28 feet; discharge, 1,330 second-feet.

*Daily gage height, in feet, of Spokane River at Spokane, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.16 | 2.83 | 5.40 | 5.63 | 8.91 | 6.31 | 4.16 | 2.15 | 1.64 | 1.40 | 1.81 | 3.27 |
| 2 | 2.16 | 2.96 | 5.38 | 6.10 | 8.81 | 6.37 | 4.07 | 2.10 | 1.70 | 1.59 | 1.84 | 3.24 |
| 3 | 2.14 | 3.10 | 5.32 | 6.36 | 8.71 | 6.41 | 3.96 | 2.09 | 1.54 | 1.52 | 1.90 | 3.20 |
| 4 | 2.13 | 3.21 | 5.24 | 6.62 | 8.60 | 6.41 | 3.87 | 2.14 | 1.53 | 1.46 | 1.67 | 3.15 |
| 5 | 2.00 | 3.32 | 5.20 | 6.77 | 8.60 | 6.37 | 3.81 | 1.73 | 1.63 | 1.49 | 1.53 | 3.28 |
| 6 | 2.03 | 3.50 | 5.12 | 6.80 | 8.51 | 6.31 | 3.72 | 1.80 | 1.59 | 1.54 | 1.82 | [a] 3.90 |
| 7 | 2.26 | 3.49 | 5.04 | 6.90 | 8.37 | 6.23 | 3.66 | 1.92 | 1.58 | 1.60 | 1.76 | 3.65 |
| 8 | 2.17 | 3.80 | 4.98 | 7.09 | 8.22 | 6.16 | 3.59 | 1.95 | 1.63 | 1.35 | 1.97 | 3.61 |
| 9 | 2.19 | 3.79 | 4.96 | 7.30 | 8.05 | 6.12 | 3.53 | 2.05 | 1.85 | 1.55 | 2.05 | 3.74 |
| 10 | 2.17 | 3.74 | 4.95 | 7.55 | 7.90 | 5.98 | 3.38 | 1.78 | 1.60 | 1.47 | 2.07 | 3.76 |
| 11 | 2.18 | 3.75 | 4.93 | 7.78 | 7.77 | 5.92 | 3.29 | 1.76 | 1.63 | 1.46 | 1.93 | 4.00 |
| 12 | 2.19 | 3.74 | 4.91 | 7.90 | 7.71 | 5.82 | 3.16 | 1.73 | 1.65 | 1.51 | 1.70 | 3.65 |
| 13 | 2.21 | 3.72 | 4.90 | 7.97 | 7.68 | 5.80 | 3.06 | 1.73 | 1.56 | 1.45 | 1.94 | 3.43 |
| 14 | 2.22 | 3.56 | 4.86 | 8.00 | 7.60 | 5.73 | 2.96 | 1.76 | 1.50 | 1.56 | 1.80 | 3.49 |
| 15 | 2.24 | 3.40 | 4.83 | 7.93 | 7.55 | 5.62 | 2.92 | 1.80 | 1.56 | 1.35 | 1.90 | 3.46 |
| 16 | 2.23 | 3.37 | 4.82 | 7.91 | 7.44 | 5.51 | 2.89 | 1.84 | 1.53 | 1.63 | 2.91 | 3.43 |
| 17 | 2.25 | 3.32 | 4.70 | 7.92 | 7.32 | 5.41 | 2.83 | 1.91 | 1.50 | 1.53 | 2.67 | 3.38 |
| 18 | 2.24 | 3.34 | 4.60 | 8.02 | 7.18 | 5.32 | 2.85 | 1.75 | 1.58 | 1.70 | 3.03 | 3.44 |
| 19 | 2.24 | 3.38 | 4.52 | 8.08 | 7.00 | 5.21 | 2.65 | 1.56 | 1.67 | 1.65 | [a] 4.59 | 3.38 |
| 20 | 2.21 | 3.70 | 4.45 | 8.11 | 6.85 | 5.11 | 2.73 | 1.77 | 1.62 | 1.71 | 3.72 | 3.45 |
| 21 | 2.21 | 4.11 | 4.37 | 8.31 | 6.70 | 5.01 | 2.58 | 1.76 | 1.43 | 1.70 | 4.20 | 3.43 |
| 22 | 2.22 | 4.47 | 4.31 | 8.33 | 6.55 | 4.93 | 2.50 | 1.95 | 1.43 | 1.63 | 4.56 | 3.50 |
| 23 | 2.24 | 4.74 | 4.22 | 8.48 | 6.46 | 4.83 | 2.47 | 1.76 | 1.42 | 1.65 | 3.90 | 3.48 |
| 24 | 2.26 | 4.97 | 4.18 | 8.80 | 6.35 | 4.74 | 2.49 | 1.63 | 1.40 | 1.63 | 4.03 | 3.51 |
| 25 | 2.29 | 5.10 | 4.18 | 9.18 | 6.25 | 4.64 | 2.38 | 1.64 | 1.65 | 1.68 | 4.06 | 3.92 |
| 26 | 2.36 | 5.24 | 4.24 | 9.23 | 6.02 | 4.52 | 2.34 | 1.70 | 1.53 | 1.66 | 4.07 | 4.20 |
| 27 | 2.47 | 5.33 | 4.35 | 9.31 | 6.04 | 4.45 | 2.25 | 1.63 | 1.57 | 1.62 | 4.05 | 4.55 |
| 28 | 2.62 | 5.39 | 4.60 | 9.22 | 6.03 | 4.36 | 2.26 | 1.76 | 1.57 | 1.81 | 4.01 | 5.00 |
| 29 | 2.67 | ..... | 4.80 | 9.11 | 5.94 | 4.32 | 2.18 | 1.65 | 1.62 | 1.54 | 3.91 | 5.50 |
| 30 | 2.73 | ..... | 5.03 | 9.04 | 6.00 | 4.25 | 2.26 | 1.68 | 1.60 | 1.70 | 3.81 | 5.65 |
| 31 | 2.78 | ..... | 5.30 | ..... | 6.05 | ..... | 2.21 | 1.60 | ..... | 1.73 | ..... | 5.70 |

[a] Backwater due to log jams.

NOTE.—The river at this point does not freeze on account of the underground flow of water which comes through the gravel above the station and into the river again.

*Rating table for Spokane River at Spokane, Wash., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.00 | 1,000 | 2.10 | 2,340 | 3.20 | 4,080 | 4.60 | 6,660 | 6.80 | 11,340 |
| 1.10 | 1,100 | 2.20 | 2,490 | 3.30 | 4,250 | 4.80 | 7,050 | 7.00 | 11,830 |
| 1.20 | 1,200 | 2.30 | 2,640 | 3.40 | 4,420 | 5.00 | 7,450 | 8.00 | 14,490 |
| 1.30 | 1,300 | 2.40 | 2,790 | 3.50 | 4,600 | 5.20 | 7,850 | 9.00 | 17,380 |
| 1.40 | 1,410 | 2.50 | 2,940 | 3.60 | 4,780 | 5.40 | 8,250 | 10.00 | 20,580 |
| 1.50 | 1,520 | 2.60 | 3,100 | 3.70 | 4,960 | 5.60 | 8,660 | 11.00 | 23,980 |
| 1.60 | 1,640 | 2.70 | 3,260 | 3.80 | 5,140 | 5.80 | 9,080 | 12.00 | 27,580 |
| 1.70 | 1,760 | 2.80 | 3,420 | 3.90 | 5,330 | 6.00 | 9,510 | | |
| 1.80 | 1,900 | 2.90 | 3,580 | 4.00 | 5,520 | 6.20 | 9,950 | | |
| 1.90 | 2,040 | 3.00 | 3,740 | 4.20 | 5,900 | 6.40 | 10,400 | | |
| 2.00 | 2,190 | 3.10 | 3,910 | 4.40 | 6,280 | 6.60 | 10,860 | | |

NOTE.—The above table is based on 22 discharge measurements made during 1904–1907 and is well defined between gage heights 1.4 feet and 12.0 feet.

*Monthly discharge of Spokane River at Spokane, Wash., for 1906.*

[Drainage area, 4,000 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 3,390 | 2,190 | 2,600 | 160,000 | 0.650 | 0.75 |
| February | 8,230 | 3,470 | 5,320 | 295,000 | 1.33 | 1.38 |
| March | 8,250 | 5,860 | 7,050 | 433,000 | 1.76 | 2.03 |
| April | 18,400 | 8,720 | 14,200 | 845,000 | 3.55 | 3.96 |
| May | 17,100 | 9,380 | 12,800 | 787,000 | 3.20 | 3.69 |
| June | 10,400 | 6,000 | 8,440 | 502,000 | 2.11 | 2.35 |
| July | 5,820 | 2,460 | 3,790 | 233,000 | .948 | 1.09 |
| August | 2,420 | 1,590 | 1,920 | 118,000 | .480 | .55 |
| September | 1,970 | 1,410 | 1,610 | 95,800 | .402 | .45 |
| October | 1,910 | 1,360 | 1,620 | 99,600 | .405 | .47 |
| November | 6,640 | 1,560 | 3,600 | 214,000 | .900 | 1.00 |
| December | 8,870 | 4,000 | 5,210 | 320,000 | 1.30 | 1.50 |
| The year | 18,400 | 1,360 | 5,680 | 4,100,000 | 1.42 | 19.22 |

NOTE.—Values are rated as excellent.

### MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in Spokane River drainage basin in 1906:

*Spokane River.*—A measurement was made at low water October 1, 1906, at Spokane Bridge, near the Idaho-Washington State line.

Width, 163 feet; area, 778 square feet; discharge, 803 second-feet.

A measurement was made at medium stage November 12, 1906, in sec. 24, T. 27 N., R. 39 E.

Width, 154 feet; area, 760 square feet; discharge, 2,500 second-feet.

## OKANOGAN RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Okanogan River rises in Okanogan Lake, in British Columbia, and flows southward, entering Columbia River near Brewster, Wash. Its course in Canada lies through a series of narrow lakes. The drainage area is comparatively rough and mountainous, and is timbered except along the river. The rainfall is approximately 20 inches per annum. The principal tributaries in the United States are Sim-

ilkameen and Conconully rivers and Antwine, Bonaparte, Salmon, and Johnson creeks.

The main stream is navigable from Brewster to Riverside except during low-water periods, while the tributaries are used largely for irrigation.

### SALMON CREEK NEAR MALOTT, WASH.

This station was established April 11, 1903. It is located opposite R. D. Jones's house, on the county road halfway between Malott and Conconully, Okanogan County. It is reached by way of the Great Northern Railway to Wenache, thence by way of the Columbia River steamers to Brewster, and by the Conconully stage from Brewster to Jones's ranch. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 32, where are given also references to publications that contain data for previous years.

*Daily gage height, in feet, of Salmon Creek near Malott, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.69 | 0.75 | 0.70 | 1.52 | 1.42 | 2.21 | 1.46 | 0.92 | 0.49 | 0.54 | 0.69 | 0.71 |
| 2 | .68 | .74 | .69 | 1.33 | 1.38 | 2.02 | 1.40 | .88 | .46 | .56 | .69 | .69 |
| 3 | .67 | .73 | .68 | 1.25 | 1.44 | 2.00 | 1.33 | .83 | .46 | .54 | .71 | .71 |
| 4 | .69 | .70 | .66 | 1.29 | 1.33 | 2.29 | 1.29 | .83 | .44 | .54 | .83 | .67 |
| 5 | .70 | .70 | .68 | 1.40 | 1.25 | 2.00 | 1.25 | .81 | .44 | .58 | 1.00 | .67 |
| 6 | .71 | .69 | .73 | 1.50 | 1.23 | 2.00 | 1.23 | .81 | .44 | .54 | .96 | .67 |
| 7 | .70 | .70 | .72 | 1.54 | 1.19 | 1.96 | 1.27 | .79 | .44 | .56 | .83 | .69 |
| 8 | .71 | .65 | .74 | 1.33 | 1.19 | 1.83 | 1.14 | .75 | .46 | .60 | .75 | .67 |
| 9 | .73 | .65 | .75 | 1.25 | 1.21 | 1.79 | 1.12 | .75 | .50 | .56 | .75 | .71 |
| 10 | .70 | .58 | .75 | 1.10 | 1.21 | 1.83 | 1.08 | .75 | .50 | .54 | .81 | .73 |
| 11 | .71 | .60 | .70 | 1.14 | 1.25 | 1.96 | .98 | .71 | .57 | .56 | .79 | .71 |
| 12 | .71 | .58 | .68 | 1.11 | 1.25 | 2.12 | 1.00 | .67 | .54 | .67 | .79 | .67 |
| 13 | .73 | .56 | .70 | 1.12 | 1.29 | 2.02 | .99 | .67 | .58 | .67 | .75 | .69 |
| 14 | .73 | .58 | .73 | 1.17 | 1.33 | 2.00 | .92 | .71 | .60 | .67 | .81 | .67 |
| 15 | .70 | .64 | .70 | 1.21 | 1.77 | 1.96 | .90 | .67 | .62 | .69 | 1.38 | .67 |
| 16 | .69 | .66 | .70 | 1.31 | 1.41 | 1.83 | .88 | .66 | .64 | .73 | 1.12 | .69 |
| 17 | .67 | .68 | .66 | 1.31 | 1.29 | 1.83 | .83 | .58 | .58 | .67 | .90 | .69 |
| 18 | .67 | .66 | .66 | 1.25 | 1.27 | 1.79 | 1.05 | .56 | .58 | .67 | .83 | .71 |
| 19 | .69 | .70 | .70 | 1.25 | 1.25 | 1.71 | 1.00 | .54 | .56 | .64 | .83 | .71 |
| 20 | .70 | .75 | .66 | 1.33 | 1.31 | 1.67 | 1.00 | .52 | .58 | .67 | .79 | .73 |
| 21 | .71 | .75 | .70 | 1.44 | 1.29 | 1.62 | 1.05 | .54 | .56 | .62 | .83 | .71 |
| 22 | .71 | .87 | .70 | 1.56 | 1.40 | 1.58 | 1.35 | .58 | .54 | .67 | .79 | .73 |
| 23 | .73 | .77 | .75 | 1.52 | 1.46 | 1.54 | 1.31 | .66 | .54 | .67 | .79 | .73 |
| 24 | .72 | .75 | .83 | 1.43 | 1.35 | 1.52 | 1.25 | .58 | .54 | .67 | .75 | .67 |
| 25 | .73 | .73 | .87 | 1.29 | 1.32 | 1.50 | 1.12 | .56 | .56 | .67 | .77 | .67 |
| 26 | .73 | .75 | .87 | 1.29 | 2.42 | 1.47 | 1.05 | .56 | .54 | .67 | .75 | .54 |
| 27 | .74 | .73 | .85 | 1.29 | 2.75 | 1.58 | 1.00 | .54 | .54 | .71 | .75 | .46 |
| 28 | .75 | .70 | .83 | 1.33 | 2.35 | 1.71 | 1.00 | .54 | .54 | .69 | .75 | .50 |
| 29 | .75 | ..... | .82 | 1.33 | 2.10 | 1.54 | .96 | .52 | .56 | .67 | .75 | .71 |
| 30 | .73 | ..... | .86 | 1.35 | 2.08 | 1.46 | .94 | .50 | .54 | .67 | .73 | .67 |
| 31 | .73 | ..... | 1.42 | ..... | 2.12 | ..... | .92 | .50 | ..... | .67 | ..... | .67 |

NOTE.—The creek never freezes at the gage.

### JOHNSON CREEK NEAR RIVERSIDE, WASH.

This station was established May 30, 1903. The weir was destroyed July 30, 1904, and the station discontinued, but it was replaced April 30, 1905, and the records resumed. It is located at

Sogle's ranch, on the road from Riverside to Conconully, 1 mile from Riverside and 17 miles from Conconully.

The right bank of the stream is low for 10 feet back from the water's edge and then it rises more abruptly. The left bank is steep and rocky. The bed of the creek is composed of small gravel.

The equipment consists of a sharp-crested weir with an 8-foot opening and vertical sides. Below the level of the crest the weir consists of two 2-inch pine planks, 12 inches wide, securely spiked together. Above the crest on each end are two planks 12 inches wide, which form the ends of the weir. The edges of the crest and ends are one-fourth inch wide and beveled on the downstream side to an angle of 60°. The pool above the weir is 10 feet long, 10 to 15 feet wide, and 1 foot deep below the crest. The water has a fall of about 1 foot after passing the weir and then flows rapidly away.

The depth of the water on the crest is determined by a hook gage and vernier reading to thousandths of a foot. The zero on the gage is 0.10 foot above the crest of the weir. During 1905 and 1906 the gage readings were made once each day by Mrs. S. Sogle. The bench mark is the top of the fence opposite the weir; elevation, 12.91 feet above zero of the gage and 1,241.54 feet above sea level.

A description of this station, with discharge data, is contained in Water-Supply Papers Nos. 100 and 135, United States Geological Survey.

*Daily discharge, in second-feet, of Johnson Creek at Riverside, Wash., for 1905–6.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905. | | | | | | | | | | | | |
| 1 | | | | | 11.7 | 6.3 | 10.8 | 6.2 | 6.1 | 8.3 | 8.0 | 9.5 |
| 2 | | | | | 11.6 | 6.3 | 10.4 | 6.7 | 6.2 | 8.3 | 8.0 | 11.3 |
| 3 | | | | | 11.4 | 9.0 | 9.9 | 6.3 | 6.4 | 7.6 | 8.0 | 11.4 |
| 4 | | | | | 11.1 | 10.4 | 8.8 | 6.2 | 5.8 | 7.4 | 7.9 | 11.5 |
| 5 | | | | | 11.0 | 9.1 | 8.1 | 6.1 | 6.1 | 8.1 | 7.9 | 7.9 |
| 6 | | | | | 10.7 | 8.8 | 6.8 | 6.0 | 5.9 | 8.7 | 7.9 | 7.9 |
| 7 | | | | | 10.7 | 8.9 | 6.5 | 5.8 | 5.9 | 9.3 | 7.9 | 8.0 |
| 8 | | | | | 10.6 | 8.7 | 6.5 | 5.6 | 6.0 | 8.1 | 8.0 | 7.9 |
| 9 | | | | | 11.1 | 8.1 | 5.6 | 5.4 | 6.4 | 7.5 | 8.0 | 8.4 |
| 10 | | | | | 10.8 | 8.0 | 5.6 | 5.4 | 6.2 | 7.3 | 8.1 | 8.5 |
| 11 | | | | | 10.7 | 9.5 | 4.6 | 6.1 | 6.1 | 7.2 | 8.1 | 8.4 |
| 12 | | | | | 9.7 | 8.3 | 5.1 | 5.8 | 6.1 | 7.1 | 8.0 | 8.4 |
| 13 | | | | | 9.5 | 7.6 | 5.0 | 5.8 | 8.3 | 6.9 | 8.1 | 8.4 |
| 14 | | | | | 6.8 | 7.1 | 6.6 | 5.6 | 8.5 | 6.8 | 8.3 | 8.0 |
| 15 | | | | | 6.1 | 6.9 | 6.6 | 5.8 | 6.9 | 7.8 | 8.3 | 8.9 |
| 16 | | | | | 7.7 | 6.9 | 4.6 | 6.0 | 7.0 | 7.4 | 8.4 | 8.3 |
| 17 | | | | | 7.7 | 6.8 | 6.8 | 6.2 | 7.6 | 7.4 | 8.4 | 8.3 |
| 18 | | | | | 6.4 | 6.8 | 7.6 | 6.2 | 7.4 | 7.5 | 8.4 | 8.7 |
| 19 | | | | | 5.9 | 6.8 | 6.4 | 6.1 | 7.0 | 7.9 | 12.5 | 9.0 |
| 20 | | | | | 6.2 | 6.7 | 5.0 | 5.8 | 7.2 | 7.9 | 12.1 | 8.8 |
| 21 | | | | | 6.7 | 6.6 | 5.3 | 5.6 | 7.3 | 7.9 | 9.7 | 8.7 |
| 22 | | | | | 7.1 | 6.8 | 5.1 | 5.4 | 7.1 | 7.9 | 8.8 | 8.0 |
| 23 | | | | | 9.5 | 6.6 | 5.1 | 5.4 | 6.3 | 8.0 | 8.7 | 7.6 |
| 24 | | | | | 9.6 | 7.3 | 5.1 | 5.6 | 6.3 | 8.1 | 8.6 | 9.0 |
| 25 | | | | | 7.1 | 9.0 | 5.1 | 6.5 | 6.3 | 7.9 | 8.7 | 8.4 |
| 26 | | | | | 8.1 | 9.5 | 5.1 | 6.6 | 7.3 | 7.9 | 8.7 | 8.4 |
| 27 | | | | | 7.2 | 13.6 | 5.4 | 6.7 | 12.5 | 7.9 | 8.3 | 8.1 |
| 28 | | | | | 7.2 | 12.2 | 6.0 | 6.7 | 12.3 | 7.9 | 7.9 | 8.0 |
| 29 | | | | | 7.1 | 11.5 | 7.0 | 6.4 | 9.1 | 8.0 | 7.9 | 7.9 |
| 30 | | | | | 4.6 | 10.8 | 6.6 | 5.7 | 8.0 | 8.0 | 9.2 | 7.9 |
| 31 | | | | | 6.1 | | 6.2 | 6.0 | | 8.0 | | 7.8 |

*Daily discharge, in second-feet, of Johnson Creek at Riverside, Wash., for 1905–6*—Cont'd.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906. | | | | | | | | | | | | |
| 1 | 4.6 | 10.1 | 9.6 | 12.2 | 3.7 | 6.4 | 3.0 | 1.0 | 3.5 | 4.1 | 4.8 | 6.1 |
| 2 | 8.3 | 9.8 | 9.5 | 9.8 | 3.3 | 5.9 | 3.2 | 1.3 | 3.4 | 4.1 | 4.9 | 6.3 |
| 3 | 8.1 | 9.7 | 9.5 | 9.1 | 2.8 | 4.8 | 2.4 | 1.3 | 3.1 | 4.2 | 5.1 | 6.4 |
| 4 | 7.9 | 9.5 | 9.6 | 8.8 | 2.8 | 6.8 | 2.4 | 1.0 | 3.0 | 4.2 | 6.8 | 6.4 |
| 5 | 7.9 | 9.2 | 9.5 | 8.7 | 1.8 | 6.1 | 4.1 | 1.0 | 2.6 | 4.3 | 8.1 | 6.6 |
| 6 | 7.9 | 8.5 | 9.5 | 8.6 | 2.1 | 5.8 | 3.0 | 1.9 | 2.8 | 4.4 | 5.7 | 7.3 |
| 7 | 6.3 | 8.9 | 9.5 | 8.5 | 2.3 | 5.6 | 3.1 | 1.3 | 2.8 | 4.6 | 5.6 | 7.1 |
| 8 | 8.1 | 8.5 | 9.5 | 8.5 | 1.9 | 5.3 | 3.0 | 1.4 | 3.1 | 4.2 | 5.7 | 6.9 |
| 9 | 8.2 | 8.4 | 9.2 | 8.4 | 2.8 | 5.3 | 1.6 | 1.4 | 3.1 | 4.2 | 6.0 | 6.6 |
| 10 | 7.9 | 8.3 | 9.0 | 8.4 | 2.7 | 4.9 | 1.6 | 1.3 | 3.1 | 4.2 | 6.8 | 6.5 |
| 11 | 14.1 | 8.3 | 8.1 | 8.3 | 3.5 | 5.1 | 1.5 | 1.4 | 3.2 | 4.3 | 6.8 | 6.9 |
| 12 | 8.4 | 8.2 | 7.7 | 8.4 | 3.4 | 5.8 | 1.3 | 1.4 | 3.4 | 4.4 | 5.7 | 6.8 |
| 13 | 8.6 | 8.3 | 8.8 | 8.4 | 3.0 | 5.4 | 1.3 | 1.4 | 4.6 | 4.4 | 5.9 | 6.6 |
| 14 | 8.5 | 8.1 | 8.3 | 8.4 | 2.9 | 5.6 | 1.3 | 1.9 | 4.9 | 4.6 | 8.4 | 6.6 |
| 15 | 8.0 | 8.6 | 7.6 | 8.3 | 5.7 | 5.7 | 1.3 | 1.7 | 4.9 | 4.4 | 7.3 | 5.6 |
| 16 | 8.2 | 8.8 | 9.5 | 8.3 | 4.5 | 6.8 | 1.3 | 1.6 | 4.4 | 4.5 | 7.3 | 5.5 |
| 17 | 8.0 | 10.4 | 8.7 | 8.1 | 4.5 | 6.2 | 1.4 | 1.4 | 4.1 | 4.5 | 6.6 | 6.7 |
| 18 | 8.1 | 12.5 | 8.5 | 8.0 | 3.9 | 5.6 | 3.1 | 1.4 | 4.4 | 4.4 | 6.4 | 8.5 |
| 19 | 33.6 | 17.5 | 8.2 | 8.0 | 3.5 | 5.2 | 3.3 | 1.7 | 4.2 | 4.4 | 6.0 | 7.9 |
| 20 | 10.1 | 13.8 | 8.5 | 8.0 | 3.4 | 5.2 | 2.4 | 1.7 | 4.3 | 4.5 | 6.1 | 7.3 |
| 21 | 7.6 | 15.8 | 8.7 | 8.0 | 1.9 | 5.0 | 2.2 | 1.7 | 4.2 | 4.6 | 6.1 | 7.2 |
| 22 | 7.9 | 13.2 | 8.8 | 7.6 | 2.0 | 4.8 | 2.8 | 2.2 | 4.2 | 4.5 | 6.2 | 7.4 |
| 23 | 9.2 | 11.3 | 8.8 | 7.9 | 3.3 | 4.7 | 2.7 | 2.6 | 4.2 | 4.5 | 6.1 | 7.3 |
| 24 | 10.1 | 10.7 | 9.2 | 7.9 | 3.7 | 4.7 | 2.6 | 2.6 | 4.4 | 4.6 | 6.0 | 7.2 |
| 25 | 10.1 | 12.2 | 9.0 | 8.0 | 3.9 | 4.2 | 2.2 | 2.4 | 4.4 | 4.6 | 6.0 | 7.2 |
| 26 | 10.0 | 10.8 | 8.7 | 7.3 | 3.8 | 3.1 | 1.5 | 3.2 | 4.3 | 4.6 | 6.1 | 7.1 |
| 27 | 9.5 | 11.3 | 8.7 | 7.1 | 9.8 | 4.3 | 1.3 | 3.8 | 4.4 | 4.6 | 5.8 | 7.0 |
| 28 | 9.1 | 10.1 | 8.7 | 6.6 | 8.8 | 4.3 | 1.4 | 2.6 | 4.1 | 4.6 | 6.1 | 7.3 |
| 29 | 9.2 | ..... | 8.7 | 5.7 | 7.1 | 3.5 | 1.0 | 2.6 | 4.1 | 4.5 | 6.1 | 7.3 |
| 30 | 9.4 | ..... | 9.0 | 5.6 | 4.9 | 3.2 | 1.0 | 3.0 | 4.1 | 4.8 | 6.0 | 7.1 |
| 31 | 9.6 | ..... | 13.0 | ..... | 6.6 | ..... | 1.4 | 3.2 | ..... | 4.7 | ..... | 3.4 |

NOTE.—These discharges were obtained from the Cippoletti weir formula, using the gage heights corrected to give the head on crest of weir.

*Monthly discharge of Johnson Creek at Riverside, Wash., for 1905–6.*

[Drainage area, 66 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| May | 11.7 | 4.6 | 8.64 | 531 | 0.131 | 0.15 |
| June | 13.6 | 6.3 | 8.36 | 497 | .127 | .14 |
| July | 10.8 | 4.6 | 6.43 | 395 | .097 | .11 |
| August | 6.7 | 5.4 | 5.99 | 368 | .091 | .10 |
| September | 12.5 | 5.8 | 7.19 | 428 | .109 | .12 |
| October | 9.3 | 6.8 | 7.81 | 480 | .118 | .14 |
| November | 12.5 | 7.9 | 8.56 | 509 | .130 | .14 |
| December | 11.5 | 7.6 | 8.65 | 532 | .131 | .15 |
| The period | ..... | ..... | ..... | 3,740 | ..... | ..... |
| 1906. | | | | | | |
| January | 33.6 | 4.6 | 9.44 | 580 | .143 | .16 |
| February | 17.5 | 8.1 | 10.4 | 578 | .158 | .16 |
| March | 13.0 | 7.6 | 9.02 | 555 | .137 | .16 |
| April | 12.2 | 5.6 | 8.16 | 486 | .124 | .14 |
| May | 9.8 | 1.8 | 3.88 | 239 | .059 | .07 |
| June | 6.8 | 3.1 | 5.18 | 308 | .078 | .09 |
| July | 3.3 | 1.0 | 2.12 | 130 | .032 | .04 |
| August | 3.8 | 1.0 | 1.88 | 116 | .028 | .03 |
| September | 4.9 | 2.6 | 3.84 | 228 | .058 | .06 |
| October | 4.8 | 4.1 | 4.44 | 273 | .067 | .08 |
| November | 8.4 | 4.8 | 6.22 | 370 | .094 | .10 |
| December | 8.5 | 3.4 | 6.78 | 417 | .103 | .12 |
| The year | 33.6 | 1.0 | 5.95 | 4,280 | .090 | 1.21 |

NOTE.—Values for 1905–6 are excellent.

## METHOW RIVER DRAINAGE BASIN.

### METHOW RIVER AT PATEROS, WASH.

Methow River heads on the eastern slope of the Cascade Range in northern Washington and flows southeast into the Columbia River. Its drainage area throughout is mountainous and heavily timbered. The rainfall varies from 40 inches at the headwaters to 20 inches near the mouth of the stream. The waters of the smaller tributaries are largely used for irrigation.

This station was originally established May 3, 1903, on a highway bridge about 1,000 feet above the mouth of the river; the first two measurements were taken from this bridge. During the summer of 1903 the bridge was washed away, and a temporary bridge 400 feet farther downstream was used in making the measurement of March 20, 1904. During the spring of 1904 this bridge also was abandoned because of its temporary nature and the poor section at this point, and a cable station was established about a mile above the mouth of the river. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 35, where are given also references to publications that contain data for previous years.

The following measurement was made December 29, 1906. There was a narrow strip of ice on each bank.

Width, 154 feet; area, 342 feet; gage height, 4.12 feet; discharge, 489 second-feet.

*Daily gage height, in feet, of Methow River at Pateros, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.9 | 3.9 | 3.9 | 4.55 | 7.35 | 8.3 | 6.4 | 4.65 | 4.15 | 4.0 | 4.45 | 4.35 |
| 2 | 3.9 | 3.9 | 3.9 | 4.55 | 7.5 | 8.3 | 6.5 | 4.6 | 4.15 | 4.0 | 4.4 | 4.35 |
| 3 | 3.9 | 3.9 | 3.95 | 4.55 | 7.8 | 8.3 | 6.6 | 4.55 | 4.1 | 4.0 | 4.4 | 4.35 |
| 4 | [a] 4.1 | 3.9 | 3.95 | 4.65 | 7.6 | 9.5 | 6.7 | 4.55 | 4.1 | 4.0 | 4.45 | 4.35 |
| 5 | 4.1 | 3.9 | 3.95 | 4.8 | 7.2 | 8.5 | 6.75 | 4.55 | 4.05 | 4.0 | 4.45 | 4.35 |
| 6 | 4.1 | 3.9 | 3.95 | 5.2 | 7.0 | 8.2 | 6.85 | 4.55 | 4.05 | 4.0 | 4.45 | 4.35 |
| 7 | 4.1 | 3.8 | 3.95 | 5.7 | 6.95 | 7.8 | 7.0 | 4.45 | 4.05 | 3.95 | 4.4 | 4.35 |
| 8 | 3.95 | 3.8 | 3.95 | 5.8 | 7.0 | 7.5 | 6.6 | 4.45 | 4.05 | 3.95 | 4.45 | 4.35 |
| 9 | 3.95 | 3.8 | 4.0 | 5.65 | 7.1 | 7.0 | 6.4 | 4.45 | 4.05 | 3.95 | 4.4 | 4.35 |
| 10 | 3.95 | 3.8 | 4.0 | 5.5 | 7.2 | 7.3 | 6.25 | 4.45 | 4.1 | 3.95 | 4.45 | 4.35 |
| 11 | 3.95 | 3.9 | 4.0 | 5.4 | 7.75 | 7.3 | 6.15 | 4.4 | 4.1 | 3.95 | 4.65 | 4.35 |
| 12 | 4.0 | 4.0 | 3.9 | 5.3 | 7.8 | 8.3 | 6.0 | 4.4 | 4.1 | 3.95 | 4.65 | 4.35 |
| 13 | 4.15 | 4.0 | 3.9 | 5.2 | 7.8 | 8.0 | 5.95 | 4.4 | 4.1 | 3.95 | 4.65 | 4.35 |
| 14 | 4.45 | 3.95 | 3.9 | 5.2 | 7.1 | 7.6 | 5.8 | 4.4 | 4.1 | 3.95 | 4.7 | 4.0 |
| 15 | 4.1 | 3.95 | 3.95 | 5.3 | 7.3 | 7.2 | 5.7 | 4.4 | 4.1 | 4.0 | 5.3 | 4.25 |
| 16 | 4.1 | 3.95 | 3.95 | 5.5 | 7.0 | 7.4 | 5.6 | 4.4 | 4.1 | 4.05 | 5.15 | 4.25 |
| 17 | 4.1 | 3.95 | 3.95 | 5.5 | 6.9 | 7.1 | 5.5 | 4.35 | 4.1 | 4.05 | 4.9 | 4.25 |
| 18 | 4.1 | 4.0 | 3.95 | 5.6 | 6.7 | 6.8 | 5.4 | 4.3 | 4.1 | 4.05 | 4.8 | 4.2 |
| 19 | 4.1 | 4.0 | 3.95 | 5.7 | 6.65 | 6.75 | 5.35 | 4.25 | 4.1 | 4.05 | 4.7 | 4.15 |
| 20 | 4.1 | 4.05 | 3.95 | 5.7 | 6.6 | 6.7 | 5.25 | 4.25 | 4.1 | 4.05 | 4.65 | 4.15 |
| 21 | 4.1 | 4.0 | 3.95 | 6.1 | 6.6 | 6.7 | 5.2 | 4.2 | 4.05 | 4.0 | 4.6 | 4.2 |
| 22 | 4.1 | 3.95 | 3.95 | 6.8 | 6.6 | 6.65 | 5.15 | 4.25 | 4.05 | 4.0 | 4.55 | 4.2 |
| 23 | 4.2 | 3.95 | 3.95 | 7.0 | 6.65 | 6.6 | 5.05 | 4.25 | 4.05 | 4.0 | 4.5 | 4.2 |
| 24 | 4.25 | 3.95 | 4.0 | 6.8 | 6.75 | 6.55 | 5.0 | 4.25 | 4.05 | 4.0 | 4.5 | 4.2 |
| 25 | 4.15 | 3.95 | 4.05 | 6.5 | 6.75 | 6.75 | 4.95 | 4.25 | 4.05 | 4.0 | 4.5 | 4.2 |
| 26 | 4.15 | 3.95 | 4.05 | 6.3 | 10.5 | 7.25 | 4.9 | 4.25 | 4.05 | 3.95 | 4.45 | 4.0 |
| 27 | 4.15 | 3.9 | 4.1 | 6.3 | 10.5 | 7.4 | 4.85 | 4.2 | 4.05 | 4.6 | 4.45 | 4.05 |
| 28 | 4.1 | 3.95 | 4.15 | 6.35 | 9.2 | 7.4 | 4.8 | 4.2 | 4.05 | 4.55 | 4.4 | 4.05 |
| 29 | 4.0 | ..... | 4.15 | 6.35 | 9.0 | 7.0 | 4.8 | 4.15 | 4.0 | 4.55 | 4.35 | 4.1 |
| 30 | 3.9 | ..... | 4.25 | 6.95 | 8.7 | 6.6 | 4.75 | 4.15 | 4.0 | 4.5 | 4.35 | 4.15 |
| 31 | 3.9 | ..... | 4.5 | ..... | 8.4 | ..... | 4.7 | 4.15 | ..... | 4.5 | ..... | 4.15 |

[a] Ice forming along banks, narrowing channel.

*Rating table for Methow River at Pateros, Wash., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.80 | 400 | 4.80 | 902 | 5.80 | 1,988 | 6.80 | 3,560 | 8.60 | 7,088 |
| 3.90 | 420 | 4.90 | 984 | 5.90 | 2,128 | 6.90 | 3,738 | 8.80 | 7,506 |
| 4.00 | 450 | 5.00 | 1,072 | 6.00 | 2,272 | 7.00 | 3,920 | 9.00 | 7,930 |
| 4.10 | 486 | 5.10 | 1,166 | 6.10 | 2,420 | 7.20 | 4,294 | 9.20 | 8,356 |
| 4.20 | 528 | 5.20 | 1,266 | 6.20 | 2,572 | 7.40 | 4,676 | 9.40 | 8,785 |
| 4.30 | 576 | 5.30 | 1,372 | 6.30 | 2,726 | 7.60 | 5,066 | 9.60 | 9,215 |
| 4.40 | 630 | 5.40 | 1,484 | 6.40 | 2,884 | 7.80 | 5,460 | 9.80 | 9,646 |
| 4.50 | 690 | 5.50 | 1,602 | 6.50 | 3,050 | 8.00 | 5,860 | 10.00 | 10,080 |
| 4.60 | 756 | 5.60 | 1,724 | 6.60 | 3,216 | 8.20 | 6,264 | | |
| 4.70 | 826 | 5.70 | 1,854 | 6.70 | 3,386 | 8.40 | 6,674 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1906 and is well defined.

*Monthly discharge of Methow River at Pateros, Wash., for 1906.*

[Drainage area, 1,710 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec-ft. per sq. mile. | Depth in inches. |
| January | 660 | 420 | 478 | 29,400 | 0.28 | 0.32 |
| February | 468 | 400 | 430 | 23,900 | .25 | .26 |
| March | 690 | 420 | 455 | 28,000 | .27 | .31 |
| April | 3,920 | 723 | 1,970 | 117,000 | 1.15 | 1.28 |
| May | 11,200 | 3,220 | 5,040 | 310,000 | 2.95 | 3.40 |
| June | 9,000 | 3,130 | 4,770 | 284,000 | 2.79 | 3.11 |
| July | 3,920 | 826 | 1,990 | 122,000 | 1.16 | 1.34 |
| August | 791 | 507 | 613 | 37,700 | .36 | .42 |
| September | 507 | 450 | 564 | 33,600 | .33 | .37 |
| October | 756 | 435 | 492 | 30,300 | .29 | .33 |
| November | 1,370 | 603 | 749 | 44,600 | .44 | .49 |
| December | 603 | 450 | 549 | 33,800 | .32 | .37 |
| The year | 11,200 | 400 | 1,510 | 1,090,000 | .88 | 12.00 |

NOTE.—Values are good.

## CHELAN RIVER DRAINAGE BASIN.

Chelan River forms the outlet of Lake Chelan, a long, narrow lake fed at the upper end by Stehekin River, which drains a portion of the eastern slopes of the Cascades. The tributaries of this lake drain a rough, mountainous area, quite heavily timbered. The lower end of the lake is 380 feet above Columbia River, to which it is joined by Chelan River, about 4 miles in length. The water supply of this stream is particularly valuable for future power development.

### CHELAN RIVER AT CHELAN, WASH.

This station was established November 6, 1903, by G. H. Bliss. It is located at the highway bridge 3,000 feet below the outlet of the lake and in the town of Chelan. A dam which has been constructed at the foot of the lake by the town of Chelan holds back the flow of water to some extent during the dry season. The conditions at the station and the bench marks are described in Water-Supply Paper

No. 178, page 38, where are given also references to publications that contain data for previous years.

The following measurement was made January 2, 1907:

Width, 206 feet; area, 1,460 feet; gage height, 5.50 feet; discharge, 920 second-feet.

*Daily gage height, in feet, of Chelan River at Chelan, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.40 | 5.70 | 5.60 | 5.85 | 7.75 | 8.45 | 7.65 | 7.20 | 6.20 | 5.75 | 5.55 | 7.15 |
| 2 | 5.40 | 5.68 | 5.60 | 5.90 | 7.90 | 8.45 | 7.70 | 7.15 | 6.15 | 5.70 | 5.50 | 7.10 |
| 3 | 5.40 | 5.65 | 5.60 | 5.90 | 8.05 | 8.50 | 7.80 | 7.15 | 6.10 | 5.70 | 5.45 | 7.05 |
| 4 | 5.40 | 5.65 | 5.60 | 5.90 | 8.20 | 8.45 | 8.00 | 7.05 | 6.10 | 5.65 | 5.40 | 7.00 |
| 5 | 5.40 | 5.65 | 5.60 | 5.95 | 8.30 | 8.40 | 8.15 | 7.00 | 6.00 | 5.60 | 5.40 | 7.00 |
| 6 | 5.38 | 5.65 | 5.55 | 6.02 | 8.35 | 8.40 | 8.25 | 6.50 | 5.95 | 5.60 | 5.40 | 7.00 |
| 7 | 5.38 | 5.65 | 5.55 | 6.40 | 8.30 | 8.35 | 8.40 | 6.50 | 5.90 | 5.55 | 5.40 | 6.95 |
| 8 | 5.40 | 5.65 | 6.65 | 6.40 | 8.30 | 8.35 | 8.50 | 6.50 | 5.90 | 5.50 | 5.40 | 6.95 |
| 9 | 5.40 | 5.65 | 6.58 | 6.50 | 8.32 | 8.35 | 8.50 | 6.50 | 5.90 | 5.55 | 5.50 | 6.90 |
| 10 | 5.40 | 5.65 | 6.50 | 6.48 | 8.40 | 8.30 | 8.45 | 6.50 | 5.85 | 5.55 | 5.50 | 6.90 |
| 11 | 5.40 | 5.60 | 6.43 | 6.52 | 8.50 | 8.30 | 8.40 | 6.50 | 5.90 | 5.60 | 5.55 | 6.85 |
| 12 | 5.45 | 5.60 | 6.38 | 6.50 | 8.65 | 8.35 | 8.40 | 6.50 | 6.00 | 5.60 | 5.65 | 6.80 |
| 13 | 5.48 | 5.60 | 6.30 | 6.50 | 8.70 | 8.35 | 8.38 | 6.45 | 6.25 | 5.60 | 5.80 | 6.70 |
| 14 | 5.48 | 5.60 | 6.25 | 6.50 | 8.70 | 8.30 | 8.35 | 6.45 | 6.15 | 5.60 | 6.10 | 6.60 |
| 15 | 5.45 | 5.65 | 6.22 | 6.55 | 8.70 | 8.30 | 8.35 | 6.40 | 6.10 | 5.60 | 6.50 | 6.55 |
| 16 | 5.50 | 5.65 | 6.20 | 6.60 | 8.65 | 8.25 | 8.35 | 6.40 | 6.00 | 5.60 | 7.00 | 6.50 |
| 17 | 5.45 | 5.65 | 6.18 | 6.65 | 8.60 | 8.20 | 8.33 | 6.35 | 5.95 | 5.60 | 7.50 | 6.40 |
| 18 | 5.45 | 5.65 | 6.10 | 6.60 | 8.55 | 8.15 | 8.30 | 6.35 | 5.95 | 5.57 | 7.70 | 6.40 |
| 19 | 5.40 | 5.65 | 6.00 | 6.70 | 8.50 | 8.10 | 8.20 | 6.30 | 5.95 | 5.55 | 7.60 | 6.35 |
| 20 | 5.40 | 5.65 | 5.92 | 6.75 | 8.40 | 7.95 | 8.10 | 6.28 | 5.95 | 5.50 | 7.50 | 6.35 |
| 21 | 5.40 | 5.60 | 5.88 | 6.82 | 8.30 | 7.75 | 8.00 | 6.25 | 5.90 | 5.45 | 7.45 | 6.30 |
| 22 | 5.40 | 5.65 | 5.85 | 7.00 | 8.25 | 7.65 | 7.90 | 6.20 | 5.90 | 5.40 | 7.40 | 6.30 |
| 23 | 5.90 | 5.65 | 5.82 | 7.15 | 8.20 | 7.50 | 7.80 | 6.15 | 5.90 | 5.40 | 7.40 | 6.30 |
| 24 | 5.85 | 5.70 | 5.80 | 7.25 | 8.15 | 7.40 | 7.70 | 6.08 | 5.85 | 5.38 | 7.40 | 6.20 |
| 25 | 5.85 | 5.65 | 5.80 | 7.35 | 8.20 | 7.50 | 7.60 | 6.60 | 5.90 | 5.80 | 7.35 | 6.10 |
| 26 | 5.80 | 5.70 | 5.78 | 7.40 | 8.35 | 7.60 | 7.60 | 6.00 | 5.85 | 5.85 | 7.35 | 6.00 |
| 27 | 5.80 | 5.70 | 5.78 | 7.42 | 8.45 | 7.70 | 7.55 | 6.05 | 5.85 | 5.90 | 7.30 | 5.90 |
| 28 | 5.75 | 5.65 | 5.75 | 7.45 | 8.50 | 7.70 | 7.50 | 6.05 | 5.80 | 5.80 | 7.25 | 5.90 |
| 29 | 5.75 | ..... | 5.72 | 7.50 | 8.50 | 7.68 | 7.50 | 6.10 | 5.78 | 5.65 | 7.20 | 5.85 |
| 30 | 5.70 | ..... | 5.72 | 7.60 | 8.50 | 7.65 | 7.40 | 6.20 | 5.75 | 5.65 | 7.20 | 5.80 |
| 31 | 5.70 | ..... | 5.82 | ..... | 8.50 | ..... | 7.30 | 6.20 | ..... | 5.60 | ..... | 5.70 |

*Rating table for Chelan River at Chelan, Wash., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 5.30 | 830 | 6.00 | 1,150 | 6.70 | 1,920 | 7.30 | 2,910 | 7.90 | 3,990 |
| 5.40 | 860 | 6.10 | 1,230 | 6.80 | 2,070 | 7.40 | 3,090 | 8.00 | 4,170 |
| 5.50 | 900 | 6.20 | 1,320 | 6.90 | 2,250 | 7.50 | 3,270 | 8.20 | 4,550 |
| 5.60 | 940 | 6.30 | 1,420 | 7.00 | 2,390 | 7.60 | 3,450 | 8.40 | 4,930 |
| 5.70 | 990 | 6.40 | 1,530 | 7.10 | 2,560 | 7.70 | 3,630 | 8.60 | 5,300 |
| 5.80 | 1,040 | 6.50 | 1,650 | 7.20 | 2,730 | 7.80 | 3,810 | 8.80 | 5,690 |
| 5.90 | 1,090 | 6.60 | 1,780 | | | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1907, and is fairly well defined above gage height 5.5 feet.

*Monthly discharge of Chelan River at Chelan, Wash., for 1906.*

[Drainage area, 950 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 1,090 | 854 | 916 | 56,300 | .964 | 1.11 |
| February | 990 | 940 | 965 | 53,600 | 1.02 | 1.06 |
| March | 1,850 | 920 | 1,170 | 71,900 | 1.23 | 1.42 |
| April | 3,450 | 1,050 | 1,990 | 118,000 | 2.09 | 2.33 |
| May | 5,500 | 3,720 | 4,890 | 301,000 | 5.15 | 5.94 |
| June | 5,110 | 3,090 | 4,330 | 258,000 | 4.56 | 5.09 |
| July | 5,110 | 2,910 | 4,210 | 259,000 | 4.43 | 5.11 |
| August | 2,730 | 1,150 | 1,620 | 99,600 | 1.71 | 1.97 |
| September | 1,370 | 992 | 1,130 | 67,200 | 1.19 | 1.33 |
| October | 1,080 | 812 | 921 | 56,600 | .969 | 1.12 |
| November | 3,630 | 820 | 1,990 | 118,000 | 2.09 | 2.33 |
| December | 2,640 | 965 | 1,750 | 108,000 | 1.84 | 2.12 |
| The year | 5,500 | 812 | 2,160 | 1,570,000 | 2.27 | 30.93 |

NOTE.—Values are good.

## WENATCHEE RIVER DRAINAGE BASIN.

### WENATCHEE RIVER AT CASHMERE, WASH.

Wenatchee River drains a portion of the western slope of the Cascade Mountains in Washington, and flows southeast through Lake Wenatchee into the Columbia River. Its basin throughout is mountainous and quite heavily timbered. The rainfall varies from 50 inches at the crest of the Cascades to 20 inches at the mouth. The waters of the stream are principally valuable for irrigation.

This station was established July 26, 1904. It is located at the highway bridge just north of the town of Cashmere, Wash. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 40, where are given also references to publications that contain data for previous years.

The old gage was destroyed by flood November 15, 1906. A new gage was installed at the same place and datum on December 27.

*Discharge measurements of Wenatchee River at Cashmere, Wash., in 1906.*

| Date. | Hydrographer | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| August 23 | W. G. Steward | 160 | 232 | 1.55 | 889 |
| August 29 | do | 161 | 737 | 1.55 | 956 |
| December 27 | H. McGlashan | 186 | 312 | 2.20 | 1,300 |

*Daily gage height, in feet, of Wenatchee River at Cashmere, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.3 | 2.4 | 2.0 | 3.6 | 6.0 | 4.6 | 3.6 | 2.2 | 1.8 | 1.5 | 3.2 | ..... |
| 2 | 1.3 | 2.5 | 2.0 | 3.5 | 6.1 | 4.6 | 3.8 | 2.1 | 1.8 | 1.4 | 2.9 | ..... |
| 3 | 1.4 | 2.6 | 2.0 | 3.3 | 6.3 | 4.9 | 4.1 | 2.0 | 1.7 | 1.5 | 2.8 | ..... |
| 4 | 1.5 | 2.5 | 1.9 | 3.4 | 6.1 | 5.5 | 4.4 | 1.9 | 1.7 | 1.7 | 2.8 | ..... |
| 5 | 1.7 | 2.5 | 1.9 | 3.6 | 5.9 | 5.3 | 4.5 | 2.0 | 1.6 | 1.7 | 2.9 | ..... |
| 6 | 1.7 | 2.4 | 2.0 | 4.0 | 5.5 | 4.9 | 4.5 | 2.0 | 1.4 | 1.7 | 2.6 | ..... |
| 7 | 1.6 | 2.4 | 2.0 | 4.4 | 5.3 | 4.6 | 4.7 | 2.0 | 1.4 | 1.7 | 2.6 | ..... |
| 8 | 1.6 | 2.3 | 2.1 | 5.0 | 5.3 | 4.4 | 4.4 | 2.0 | 1.9 | 1.6 | 2.7 | ..... |
| 9 | 1.5 | 2.2 | 2.2 | 4.6 | 5.4 | 4.2 | 4.1 | 2.0 | 2.4 | 1.5 | 2.7 | ..... |
| 10 | 1.5 | 2.1 | 2.3 | 4.3 | 5.9 | 4.1 | 3.9 | 2.0 | 2.3 | 1.6 | 2.7 | ..... |
| 11 | 1.5 | 2.1 | 2.3 | 4.2 | 6.2 | 4.0 | 3.7 | 2.0 | 2.0 | 1.5 | 3.4 | ..... |
| 12 | 1.4 | 2.1 | 2.2 | 4.1 | 6.0 | 4.9 | 3.6 | 2.0 | 1.7 | 1.5 | 3.4 | ..... |
| 13 | 1.4 | 2.0 | 2.1 | 4.0 | 5.8 | 5.0 | 3.6 | 2.0 | 1.6 | 1.7 | 5.7 | ..... |
| 14 | 1.3 | 2.0 | 2.1 | 3.8 | 5.3 | 4.6 | 3.5 | 2.1 | 1.6 | 1.8 | 8.05 | ..... |
| 15 | 1.4 | 2.0 | 2.0 | 3.9 | 5.3 | 4.3 | 3.4 | 2.0 | 1.6 | 2.0 | ..... | ..... |
| 16 | 1.4 | 1.9 | 2.0 | 4.2 | 4.9 | 4.3 | 3.3 | 1.9 | 1.6 | 2.4 | ..... | ..... |
| 17 | 1.4 | 1.9 | 2.0 | 4.4 | 4.6 | 4.2 | 3.2 | 1.85 | 1.5 | 2.7 | ..... | ..... |
| 18 | 1.4 | 2.0 | 2.0 | 4.3 | 4.4 | 4.0 | 3.1 | 1.8 | 1.5 | 3.0 | ..... | ..... |
| 19 | 1.3 | 2.3 | 2.0 | 4.3 | 4.3 | 3.9 | 3.0 | 1.6 | 1.4 | 2.8 | ..... | ..... |
| 20 | 1.3 | 2.5 | 2.0 | 4.4 | 4.2 | 3.8 | 2.9 | 1.6 | 1.4 | 2.7 | ..... | ..... |
| 21 | 1.3 | 2.4 | 2.0 | 4.8 | 4.2 | 3.8 | 2.8 | 1.6 | 1.4 | 2.3 | ..... | ..... |
| 22 | 1.4 | 2.3 | 2.0 | 5.85 | 4.1 | 3.8 | 2.7 | 1.6 | 1.4 | 2.2 | ..... | ..... |
| 23 | 1.5 | 2.3 | 2.0 | 5.8 | 4.2 | 3.8 | 2.7 | 1.6 | 1.4 | 2.1 | ..... | ..... |
| 24 | 1.8 | 2.2 | 2.0 | 5.6 | 4.2 | 3.9 | 2.6 | 1.5 | 1.4 | 2.0 | ..... | ..... |
| 25 | 2.3 | 2.2 | 2.1 | 5.3 | 4.3 | 4.1 | 2.5 | 1.5 | 1.5 | 1.8 | ..... | ..... |
| 26 | 2.4 | 2.1 | 2.2 | 5.0 | 5.4 | 4.4 | 2.5 | 1.6 | 1.8 | 6.5 | ..... | ..... |
| 27 | 2.4 | 2.1 | 2.3 | 4.9 | 5.5 | 4.3 | 2.4 | 1.7 | 1.8 | 6.0 | ..... | 2.2 |
| 28 | 2.3 | 2.1 | 2.4 | 4.9 | 5.2 | 4.2 | 2.3 | 1.7 | 1.6 | 5.0 | ..... | 2.2 |
| 29 | 2.3 | ..... | 2.5 | 5.3 | 4.9 | 3.9 | 2.3 | 1.8 | 1.5 | 4.3 | ..... | 2.1 |
| 30 | 2.2 | ..... | 2.7 | 5.6 | 4.8 | 3.7 | 2.3 | 1.8 | 1.4 | 3.8 | ..... | 2.1 |
| 31 | 2.3 | ..... | 3.4 | ..... | 4.7 | ..... | 2.3 | 1.8 | ..... | 3.5 | ..... | 2.1 |

*Rating table for Wenatchee River at Cashmere, Wash., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.00 | 550 | 2.00 | 1,360 | 3.00 | 2,450 | 4.00 | 3,800 | 6.00 | 6,900 |
| 1.10 | 615 | 2.10 | 1,460 | 3.10 | 2,580 | 4.20 | 4,100 | 6.20 | 7,240 |
| 1.20 | 685 | 2.20 | 1,560 | 3.20 | 2,710 | 4.40 | 4,400 | 6.40 | 7,580 |
| 1.30 | 755 | 2.30 | 1,665 | 3.30 | 2,840 | 4.60 | 4,700 | 6.60 | 7,920 |
| 1.40 | 830 | 2.40 | 1,770 | 3.40 | 2,970 | 4.80 | 5,000 | 6.80 | 8,260 |
| 1.50 | 910 | 2.50 | 1,875 | 3.50 | 3,100 | 5.00 | 5,300 | 7.00 | 8,600 |
| 1.60 | 990 | 2.60 | 1,985 | 3.60 | 3,240 | 5.20 | 5,620 | 8.00 | 10,400 |
| 1.70 | 1,075 | 2.70 | 2,095 | 3.70 | 3,380 | 5.40 | 5,940 | | |
| 1.80 | 1,165 | 2.80 | 2,210 | 3.80 | 3,520 | 5.60 | 6,260 | | |
| 1.90 | 1,260 | 2.90 | 2,330 | 3.90 | 3,660 | 5.80 | 6,580 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904-1906 and is well defined between gage heights 1.5 feet and 3.9 feet.

*Monthly discharge of Wenatchee River at Cashmere, Wash., for 1906.*

[Drainage area, 1,190 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 1,770 | 755 | 1,060 | 65,200 | 0.891 | 1.03 |
| February | 1,980 | 1,260 | 1,910 | 106,000 | 1.61 | 1.68 |
| March | 2,970 | 1,260 | 1,520 | 93,500 | 1.28 | 1.48 |
| April | 6,660 | 2,840 | 4,540 | 270,000 | 3.82 | 4.26 |
| May | 7,410 | 3,950 | 5,600 | 344,000 | 4.71 | 5.43 |
| June | 6,100 | 3,380 | 4,310 | 256,000 | 3.62 | 4.04 |
| July | 4,850 | 1,660 | 2,920 | 180,000 | 2.45 | 2.82 |
| August | 1,560 | 910 | 1,220 | 75,000 | 1.03 | 1.19 |
| September | 1,770 | 830 | 1,030 | 61,300 | .866 | .97 |
| October | 7,750 | 830 | 2,060 | 127,000 | 1.73 | 1.99 |
| November 1-14 | 10,500 | 1,980 | 3,210 | 89,100 | 2.70 | 1.41 |
| December 27-31 | 1,560 | 1,460 | 1,500 | 14,900 | 1.26 | .23 |
| The period | ..... | ..... | ..... | 1,680,000 | ..... | ..... |

NOTE.—Values are rated as follows: January to March and July to November, excellent; April to June, good.

## YAKIMA RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Yakima River rises in Lake Keechelus, near the crest of the eastern slope of the Cascade Mountains, in Washington, and flows southeast into the Columbia River at Kennewick. The headwaters of this stream are fed by numerous tributaries draining rough mountainous areas of heavy timber lands. It is fed near its source by Kachess River, which heads in Lake Kachess, and by Clealum River, which flows through Lake Clealum. Throughout the arid portion of this drainage area the country is timberless and rolling except in the immediate valleys of the streams. The annual rainfall varies from 100 inches at the crest of the Cascades to 10 inches near the mouth of the river. The entire summer flow of the Yakima and also that of its principal tributary, Naches River, is diverted for the irrigation of lands which have reached a high stage of development, rivaled only by the orange lands of southern California.

Gaging stations are maintained as follows:

Yakima River near Martin, Clealum, Umtanum, Yakima, Prosser, Kiona, and Richland, Wash.; Kachess River near Easton, Wash.; Clealum River near Roslyn; Nachez River near Nile and North Yakima; Bumping River near Nile; and Tieton River near Natchez (two stations). Gages for determining fluctuations of water level are maintained in Lakes Keechelus, Kachess, and Clealum.

### YAKIMA RIVER NEAR MARTIN, WASH.

This station was established October 18, 1903. It is 1,000 feet below the outlet of Lake Keechelus, 800 feet below the dam of the Cascade Lumber Company, and 4 miles northwest of Martin, Wash. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 43, where are given also references to publications that contain data for previous years.

*Discharge measurements of Yakima River near Martin, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 18 | J. C. Stevens | 113 | 191 | 7.04 | 194 |
| May 2 | W. C. Muldrow | 120 | 394 | 8.74 | 983 |
| July 17 | ....do | 108 | 186 | 6.90 | 169 |
| August 11 | ....do | 105 | 133 | 6.43 | 68 |
| August 21[a] | J. C. Stevens | 48 | 45 | 6.37 | 66 |
| October 30 | W. C. Muldrow | 119 | 295 | 8.01 | 582 |
| November 25 | ....do | 109 | 208 | 7.18 | 246 |

[a] Made 500 feet below cable.

*Daily gage height, in feet, of Yakima River near Martin, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.86 | 7.40 | 7.26 | 7.45 | 8.79 | 7.91 | 7.39 | 6.52 | 6.32 | 6.52 | 7.56 | 6.55 |
| 2 | 6.82 | 7.32 | 7.22 | 7.50 | 8.75 | 7.90 | 7.39 | 6.52 | 6.31 | 6.54 | 7.29 | 6.52 |
| 3 | 6.80 | 7.27 | 7.15 | 7.48 | 8.72 | 7.91 | 7.39 | 6.50 | 6.31 | 6.62 | 7.24 | 6.52 |
| 4 | 6.82 | 7.21 | 7.10 | 7.48 | 8.70 | 8.01 | 7.36 | 6.50 | 6.30 | 6.79 | 7.21 | ..... |
| 5 | 6.86 | 7.17 | 7.07 | 7.56 | 8.59 | 7.98 | 7.34 | 6.48 | 6.30 | 6.82 | 7.14 | ..... |
| 6 | 6.92 | 7.14 | 7.04 | 7.71 | 8.44 | 7.94 | 7.32 | 6.47 | 6.28 | 6.80 | 6.94 | ..... |
| 7 | 6.90 | 7.13 | 7.03 | 7.90 | 8.36 | 7.90 | 7.26 | 6.47 | 6.34 | 6.76 | 7.10 | ..... |
| 8 | 6.90 | 7.12 | 7.04 | 8.01 | 8.31 | 7.82 | 7.22 | 6.46 | 6.34 | 6.72 | 7.22 | 6.80 |
| 9 | 6.92 | 7.10 | 7.10 | 8.05 | 8.38 | 7.76 | 7.16 | 6.45 | 6.36 | 6.69 | 7.31 | 6.90 |
| 10 | 6.91 | 7.10 | 7.12 | 8.01 | 8.52 | 7.71 | 7.13 | 6.44 | 6.36 | 6.74 | 7.70 | 6.91 |
| 11 | 6.90 | 7.08 | 7.15 | 7.92 | 8.58 | 7.70 | 7.11 | 6.43 | 6.34 | 6.71 | 8.04 | 7.67 |
| 12 | 6.88 | 7.06 | 7.16 | 7.82 | 8.54 | 7.79 | 7.05 | 6.43 | 6.33 | 6.74 | 8.50 | 8.20 |
| 13 | 6.88 | 7.04 | 7.14 | 7.73 | 8.40 | 7.74 | 7.02 | 6.42 | 6.32 | 6.72 | 11.28 | 7.91 |
| 14 | 6.85 | 7.04 | 7.12 | 7.66 | 8.26 | 7.71 | 6.99 | 6.42 | 6.50 | 6.66 | 13.80 | 7.40 |
| 15 | 6.84 | 7.02 | 7.08 | 7.66 | 8.28 | 7.66 | 6.94 | 6.40 | 6.52 | 6.79 | 13.96 | 7.62 |
| 16 | 6.88 | 7.02 | 7.06 | 7.62 | 8.18 | 7.62 | 6.92 | 6.40 | 6.50 | 7.04 | 11.74 | 7.40 |
| 17 | 6.88 | 7.04 | 7.06 | 7.78 | 8.13 | 7.59 | 6.89 | 6.40 | 6.48 | 7.61 | 10.04 | 7.75 |
| 18 | 7.00 | 7.08 | 7.04 | 7.84 | 8.02 | 7.56 | 6.85 | 6.39 | 6.46 | 7.81 | 9.14 | 7.63 |
| 19 | 7.10 | 7.37 | 7.04 | 7.86 | 7.93 | 7.54 | 6.81 | 6.38 | 6.45 | 7.80 | 8.42 | 7.02 |
| 20 | 7.20 | 7.50 | 7.01 | 7.92 | 7.88 | 7.52 | 6.78 | 6.38 | 6.44 | 7.71 | 8.06 | 7.72 |
| 21 | 7.42 | 7.53 | 6.98 | 8.34 | 7.82 | 7.51 | 6.76 | 6.37 | 6.42 | 7.58 | 7.71 | 8.25 |
| 22 | 7.58 | 7.52 | 6.96 | 8.64 | 7.80 | 7.57 | 6.74 | 6.36 | 6.42 | 7.46 | 7.39 | 8.15 |
| 23 | 7.75 | 7.50 | 6.96 | 8.73 | 7.74 | 7.54 | 6.72 | 6.35 | 6.41 | 7.44 | 7.21 | 7.99 |
| 24 | 7.82 | 7.50 | 6.94 | 8.62 | 7.73 | 7.52 | 6.67 | 6.34 | 6.42 | 7.42 | 6.92 | 7.93 |
| 25 | 7.85 | 7.46 | 6.92 | 8.56 | 7.82 | 7.50 | 6.64 | 6.34 | 6.48 | 7.52 | 7.18 | 7.85 |
| 26 | 7.82 | 7.39 | 6.94 | 8.48 | 8.06 | 7.46 | 6.62 | 6.33 | 6.51 | 7.62 | 7.11 | ..... |
| 27 | 7.79 | 7.35 | 6.98 | 8.41 | 8.09 | 7.44 | 6.60 | 6.33 | 6.52 | 7.82 | 7.08 | ..... |
| 28 | 7.71 | 7.30 | 7.01 | 8.39 | 8.02 | 7.42 | 6.58 | 6.33 | 6.54 | 7.91 | 6.79 | ..... |
| 29 | 7.63 | ..... | 7.04 | 8.44 | 7.94 | 7.42 | 6.56 | 6.32 | 6.52 | 8.01 | ..... | ..... |
| 30 | 7.55 | ..... | 7.11 | 8.60 | 8.00 | 7.40 | 6.55 | 6.32 | 6.52 | 7.78 | 6.56 | ..... |
| 31 | 7.46 | ..... | 7.28 | ..... | 7.97 | ..... | 6.54 | 6.32 | ..... | 7.62 | ..... | 8.40 |

NOTE.—Water was entirely shut off at the lake November 29, December 4 to 7, and December 26 to 30, and for partial days at other times in December. Gage heights November 12 to 17 were computed by plotting several readings a day and taking the mean from the curve.

*Rating table for Yakima River near Martin, Wash., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 6.20 | 42 | 7.00 | 180 | 7.80 | 470 | 8.60 | 890 | 9.80 | 1,730 |
| 6.30 | 54 | 7.10 | 207 | 7.90 | 515 | 8.70 | 950 | 10.00 | 1,900 |
| 6.40 | 66 | 7.20 | 237 | 8.00 | 560 | 8.80 | 1,010 | 11.00 | 2,800 |
| 6.50 | 80 | 7.30 | 270 | 8.10 | 610 | 8.90 | 1,075 | 12.00 | 3,850 |
| 6.60 | 96 | 7.40 | 306 | 8.20 | 660 | 9.00 | 1,140 | 13.00 | 5,000 |
| 6.70 | 114 | 7.50 | 345 | 8.30 | 715 | 9.20 | 1,275 | 14.00 | 6,200 |
| 6.80 | 134 | 7.60 | 385 | 8.40 | 770 | 9.40 | 1,415 | | |
| 6.90 | 156 | 7.70 | 425 | 8.50 | 830 | 9.60 | 1,570 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904-1906, and is well defined between gage heights 6.2 feet and 9.0 feet.

*Monthly discharge of Yakima River near Martin, Wash., for 1906.*

[Drainage area, 56 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 492 | 134 | 250 | 15,400 | 4.46 | 5.14 |
| February | 357 | 185 | 255 | 14,200 | 4.55 | 4.74 |
| March | 263 | 161 | 200 | 12,300 | 3.57 | 4.12 |
| April | 968 | 326 | 581 | 34,600 | 10.38 | 11.58 |
| May | 1,000 | 438 | 682 | 41,900 | 12.18 | 14.04 |
| June | 565 | 306 | 416 | 24,800 | 7.43 | 8.29 |
| July | 302 | 86 | 177 | 10,900 | 3.16 | 3.64 |
| August | 83 | 56 | 67.3 | 4,140 | 1.20 | 1.38 |
| September | 86 | 52 | 68.9 | 4,100 | 1.23 | 1.37 |
| October | 565 | 83 | 265 | 16,300 | 4.73 | 5.45 |
| November | 6,150 | 0 | 979 | 58,300 | 17.48 | 19.51 |
| December | 770 | 0 | 272 | 16,700 | 4.86 | 5.60 |
| The year | 6,150 | 0 | 351 | 254,000 | 6.27 | 84.86 |

NOTE.—Values are rated as follows: January to October, excellent; November and December, fair.

## YAKIMA RIVER AT CLEALUM, WASH.

This station was established August 25, 1906. It is located at the highway bridge just above the town of Clealum. It is below the principal tributaries which drain the upper portion of its basin, and shows the water supply available for the Kittitas Valley.

The channel is straight for about 300 feet above and below the station. The current is swift. The right bank is low and liable to overflow; the left is high and rocky; both banks are wooded. The bed of the stream is of cobblestones and gravel and not likely to change except during high floods. There is one channel at all stages.

Measurements are made from the bridge. The initial point for soundings is the center of the downstream pier on the right bank.

A chain gage is fastened to the bridge and is read by T. J. Denny. The bench mark is a spike in a 30-inch cottonwood tree, 30 feet downstream from the right-bank pier; elevation, 8.80 feet above the datum of the gage.

*Discharge measurements of Yakima River at Clealum, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| August 24 | J. C. Stevens | 190 | 225 | 2.27 | 483 |
| September 25 | W. C. Muldrow | 190 | 226 | 2.20 | 470 |
| October 31 | do | 209 | 546 | 3.92 | 2,230 |

*Daily gage height, in feet, of Yakima River at Clealum, Wash., for 1906.*

| Day. | Aug. | Sept. | Oct. | Nov. | Dec. | Day. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 2.30 | 2.28 | 3.62 | 6.80 | 17 | | 2.30 | 2.80 | | 3.78 |
| 2 | | 2.30 | 2.25 | 3.48 | 6.70 | 18 | | 2.28 | 3.05 | | 3.80 |
| 3 | | 2.30 | 2.25 | 3.38 | 6.62 | 19 | | 2.25 | 3.20 | | 3.80 |
| 4 | | 2.28 | 2.32 | 3.28 | 6.50 | 20 | | 2.25 | 3.20 | | 4.10 |
| 5 | | 2.25 | 2.40 | 3.02 | 6.50 | 21 | | 2.22 | 3.12 | | 4.60 |
| 6 | | 2.25 | 2.40 | 2.88 | 6.50 | 22 | | 2.20 | 3.00 | | 4.90 |
| 7 | | 2.25 | 2.40 | 2.95 | 6.50 | 23 | | 2.20 | 3.00 | | 4.80 |
| 8 | | 2.25 | 2.40 | 3.10 | 6.55 | 24 | 2.25 | 2.20 | 3.00 | | 4.70 |
| 9 | | 2.28 | 2.40 | 3.08 | 5.28 | 25 | 2.30 | 2.25 | 2.95 | | 4.60 |
| 10 | | 2.28 | 2.40 | 3.30 | 4.05 | 26 | 2.30 | 2.30 | 5.50 | | 4.25 |
| 11 | | 2.25 | 2.40 | 3.85 | 4.00 | 27 | 2.30 | 2.30 | 6.00 | | 4.05 |
| 12 | | 2.25 | 2.40 | 4.22 | 4.20 | 28 | 2.30 | 2.30 | 5.25 | 7.15 | 4.00 |
| 13 | | 2.25 | 2.40 | 6.68 | 4.35 | 29 | 2.30 | 2.30 | 4.60 | 7.00 | 3.95 |
| 14 | | 2.30 | 2.40 | | 4.20 | 30 | 2.30 | 2.30 | 4.15 | 6.82 | 3.90 |
| 15 | | 2.30 | 2.45 | | 3.95 | 31 | 2.30 | | 3.80 | | 2.75 |
| 16 | | 2.30 | 2.55 | | 4.05 | | | | | | |

*Rating table for Yakima River at Clealum, Wash., from August 24 to October 25, 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.00 | 330 | 2.30 | 505 | 2.60 | 730 | 2.90 | 1,000 | 3.20 | 1,310 |
| 2.10 | 380 | 2.40 | 575 | 2.70 | 815 | 3.00 | 1,100 | | |
| 2.20 | 440 | 2.50 | 650 | 2.80 | 905 | 3.10 | 1,200 | | |

NOTE.—The above table is based on 3 discharge measurements made during 1906 and is not well defined.

*Monthly discharge of Yakima River at Clealum, Wash., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| August 24-31 | 505 | 472 | 501 | 7,950 |
| September | 505 | 440 | 484 | 28,800 |
| October 1–25 | 1,310 | 472 | 770 | 38,200 |
| The period | | | | 75,000 |

NOTE.—Values are good.

## YAKIMA RIVER AT UMTANUM, WASH.

This station was established August 25, 1906. It is located in a canyon about 100 yards from the railroad tracks and opposite the station at Umtanum, about 6 miles above Roza, on the Northern Pacific Railroad. The station is below Kittitas Valley and above Selah and Yakima valleys.

The channel is straight for about 200 feet above and below the station. There is a riffle control about 300 feet below. The right bank is low and liable to overflow to the railroad embankment; the left is high and rocky. The right half of the bed of the stream is composed of gravel and cobblestones; the left is of solid rock. There is one channel at all stages.

Discharge measurements are made from a cable and car. There is a stay line 75 feet upstream from the cable. The initial point for soundings is the face of a small cottonwood tree 10 inches in diameter, 15 feet upstream from the gage, on the right bank, about 25 feet from the water's edge.

The gage, which was read during the season by B. F. Cummings, is a 2 by 4 inch timber fastened in a vertical position on the right b nk, back of the section house. The bench mark is a mark on a bowlder 100 feet west of the section house and 40 feet north of the Northern Pacific track, opposite the gage; elevation, 16.30 feet above the datum of the gage.

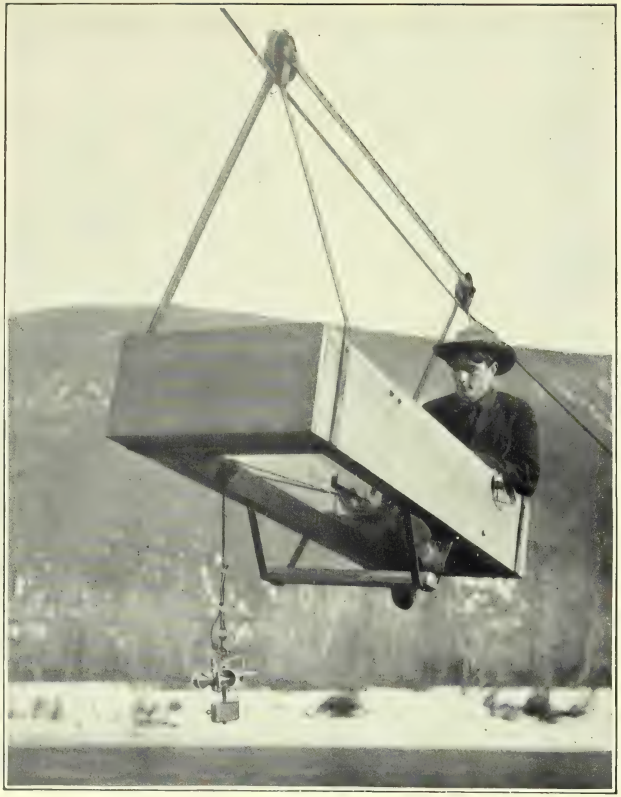
The following measurement was made August 25, 1906:

Width, 230 feet; area, 414 feet; gage height, 3.07 feet; discharge, 365 second-feet.

*Daily gage height, in feet, of Yakima River at Umtanum, Wash., for 1906.*

| Day. | Aug. | Sept. | Oct. | Nov. | Dec. | Day. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 2.98 | 3.20 | 4.55 | 5.88 | 17 | | 3.08 | 3.55 | | 4.56 |
| 2 | | 2.98 | 3.22 | 4.46 | 5.72 | 18 | | 3.08 | 3.70 | | 4.61 |
| 3 | | 3.00 | 3.25 | 4.34 | 5.50 | 19 | | 3.10 | 4.00 | | 4.66 |
| 4 | | 3.00 | 3.28 | 4.30 | 5.18 | 20 | | 3.10 | 4.10 | | 4.80 |
| 5 | | 2.99 | 3.31 | 4.12 | 5.05 | 21 | | 3.06 | 4.08 | | 5.00 |
| 6 | | 2.98 | 3.38 | 4.08 | 4.88 | 22 | | 3.06 | 4.05 | | 5.06 |
| 7 | | 2.98 | 3.48 | 4.00 | 4.68 | 23 | | 3.06 | 4.00 | | 5.04 |
| 8 | | 2.98 | 3.45 | 4.08 | 4.52 | 24 | | 3.10 | 3.96 | | 5.11 |
| 9 | | 2.98 | 3.45 | 4.15 | 4.56 | 25 | 3.07 | 3.12 | 3.88 | | 5.16 |
| 10 | | 2.97 | 3.42 | 4.32 | 4.70 | 26 | 3.00 | 3.16 | 4.88 | | 5.13 |
| 11 | | 2.98 | 3.40 | 4.45 | 4.70 | 27 | 3.00 | 3.20 | 6.40 | | 5.00 |
| 12 | | 3.04 | 3.40 | 5.18 | 4.71 | 28 | 3.03 | 3.24 | 6.00 | 6.20 | 4.92 |
| 13 | | 3.06 | 3.40 | 6.78 | 4.69 | 29 | 3.00 | 3.22 | 5.30 | 6.01 | 4.82 |
| 14 | | 3.10 | 3.42 | 9.66 | 4.65 | 30 | 3.00 | 3.20 | 4.95 | 5.94 | 4.60 |
| 15 | | 3.10 | 3.45 | | 4.62 | 31 | 2.95 | | 4.75 | | 4.34 |
| 16 | | 3.07 | 3.45 | 14.2 | 4.59 | | | | | | |

NOTE.—The upper portion of the gage was washed away November 15, so that no readings could be obtained until the 28th. The gage height of November 16 is the maximum.



A. CABLE STATION, YAKIMA RIVER, NEAR UNION GAP, WASHINGTON.

B. DISCHARGE MEASUREMENT BY WADING.

### YAKIMA RIVER NEAR YAKIMA, WASH.

The station was originally established August 14, 1893, at the county bridge at Union Gap (Pl. III, *A*), 2 miles below Yakima, Wash. In August, 1895, a cable and new gage were installed about 1,000 feet below the bridge, and about 3 miles above the intake of the Sunnyside Canal. The station is of value, as it is the only point near the large irrigated areas above and below which is unaffected by the diversion of water. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 46, where are given also references to publications that contain data for previous years.

*Discharge measurements of Yakima River near Yakima, Wash., in 1905–1907.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 19 | W. J. Lightfoot | 236 | 1,340 | 6.10 | 3,920 |
| September 2 | W. C. Muldrow | 230 | 753 | 3.64 | 780 |
| October 26 | do | 240 | 1,250 | 5.60 | 3,570 |
| November 18 | Sawyer and Muldrow | 238 | 960 | 4.32 | 1,600 |
| 1906. | | | | | |
| March 26 | J. C. Stevens | 240 | 1,190 | 5.29 | 2,900 |
| April 30 | W. C. Muldrow | 340 | 1,800 | 7.62 | 9,790 |
| July 9 | do | 241 | 1,100 | 5.14 | 2,840 |
| August 3 | do | 232 | 687 | 3.52 | 748 |
| September 29 | Stevens and Grover | 234 | 723 | 3.60 | 790 |
| October 27 | Muldrow and McGlashan | 249 | 1,620 | 7.29 | 6,770 |
| December 29 | W. C. Muldrow | 242 | 1,810 | 5.68 | 4,040 |
| 1907. | | | | | |
| February 20 | W. C. Muldrow | 300 | 2,190 | 7.03 | 7,740 |
| February 22 | do | 300 | 2,410 | 7.69 | 9,770 |

*Daily gage height, in feet, of Yakima River near Yakima, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.1 | 5.85 | 5.9 | 7.6 | 8.0 | 6.2 | 5.7 | 3.6 | 3.4 | 3.55 | 5.4 | 5.7 |
| 2 | 4.1 | 5.9 | 5.8 | 7.4 | 8.1 | 6.2 | 5.0 | 3.5 | 3.4 | 3.5 | 5.25 | 5.6 |
| 3 | 4.1 | 5.9 | 5.6 | 7.2 | 8.2 | 6.6 | 5.1 | 3.5 | 3.35 | 3.6 | 5.15 | 5.5 |
| 4 | 4.05 | 6.0 | 5.4 | 7.1 | 8.1 | 6.8 | 5.0 | 3.5 | 3.35 | 3.65 | 5.0 | 5.3 |
| 5 | 4.1 | 6.0 | 5.3 | 7.3 | 8.0 | 6.9 | 5.1 | 3.4 | 3.35 | 3.8 | 4.8 | 5.2 |
| 6 | 4.15 | 5.9 | 5.2 | 7.9 | 8.0 | 6.6 | 5.2 | 3.4 | 3.35 | 3.9 | 5.0 | 5.15 |
| 7 | 4.2 | 5.8 | 5.2 | 8.1 | 7.9 | 6.3 | 5.3 | 3.45 | 3.4 | 3.9 | 5.3 | 5.15 |
| 8 | 4.2 | 5.6 | 5.6 | 8.2 | 7.6 | 6.1 | 5.2 | 3.45 | 3.4 | 3.9 | 5.3 | 5.6 |
| 9 | 4.2 | 5.5 | 5.8 | 8.2 | 7.4 | 6.0 | 5.1 | 3.45 | 3.4 | 3.9 | 5.4 | 5.5 |
| 10 | 4.2 | 5.45 | 5.8 | 7.9 | 7.4 | 6.0 | 5.0 | 3.45 | 3.45 | 3.85 | 5.4 | 5.5 |
| 11 | 4.2 | 5.3 | 5.7 | 7.7 | 7.8 | 5.9 | 5.0 | 3.45 | 3.4 | 3.9 | 6.2 | 5.55 |
| 12 | 4.2 | 5.3 | 5.7 | 7.4 | 7.6 | 5.9 | 4.9 | 3.55 | 3.4 | 3.9 | 6.9 | 5.4 |
| 13 | 4.2 | 5.1 | 5.6 | 7.3 | 7.6 | 6.0 | 4.8 | 3.45 | 3.4 | 3.9 | 10.84 | 5.3 |
| 14 | 4.1 | 5.0 | 5.5 | 7.1 | 7.4 | 6.1 | 4.9 | 3.5 | 3.5 | 3.9 | 13.36 | 5.3 |
| 15 | 4.1 | 5.0 | 5.5 | 7.0 | 7.0 | 6.0 | 4.9 | 3.55 | 3.55 | 3.9 | 15.68 | 5.2 |
| 16 | 4.1 | 5.0 | 5.4 | 7.2 | 6.9 | 6.0 | 4.6 | 3.5 | 3.55 | 4.0 | 14.18 | 5.2 |
| 17 | 4.1 | 5.05 | 5.4 | 7.4 | 6.6 | 5.9 | 4.5 | 3.5 | 3.55 | 4.3 | 11.94 | 5.1 |
| 18 | 4.1 | 5.2 | 5.3 | 7.3 | 6.4 | 5.9 | 4.5 | 3.45 | 3.5 | 4.5 | 10.2 | 5.0 |
| 19 | 4.0 | 5.8 | 5.2 | 7.3 | 6.2 | 5.8 | 4.5 | 3.45 | 3.5 | 4.6 | 8.9 | 5.0 |
| 20 | 4.05 | 6.0 | 5.2 | 7.4 | 6.1 | 5.8 | 4.4 | 3.45 | 3.5 | 4.6 | 8.6 | 6.3 |
| 21 | 4.1 | 6.0 | 5.15 | 7.7 | 6.0 | 5.7 | 4.4 | 3.45 | 3.5 | 4.6 | 8.0 | 6.5 |
| 22 | 4.3 | 6.1 | 5.1 | 7.9 | 6.0 | 5.6 | 4.2 | 3.4 | 3.5 | 4.55 | 7.4 | 6.5 |
| 23 | 4.4 | 6.2 | 5.1 | 8.3 | 5.9 | 5.4 | 4.1 | 3.35 | 3.55 | 4.5 | 7.1 | 6.7 |
| 24 | 4.7 | 6.2 | 5.1 | 8.6 | 5.9 | 5.4 | 4.0 | 3.4 | 3.55 | 4.5 | 6.9 | 6.6 |
| 25 | 5.1 | 6.2 | 5.1 | 8.1 | 5.9 | 5.5 | 4.0 | 3.4 | 3.5 | 4.55 | 6.7 | 6.5 |
| 26 | 5.3 | 6.1 | 5.2 | 7.9 | 6.3 | 5.5 | 3.9 | 3.4 | 3.5 | 4.6 | 6.3 | 6.4 |
| 27 | 5.3 | 6.0 | 5.6 | 7.5 | 7.0 | 5.5 | 3.9 | 3.35 | 3.55 | 7.3 | 6.1 | 6.3 |
| 28 | 5.5 | 6.0 | 5.8 | 7.5 | 6.9 | 5.4 | 3.8 | 3.35 | 3.55 | 7.3 | 6.0 | 6.0 |
| 29 | 5.5 | ..... | 6.0 | 7.6 | 6.8 | 5.3 | 3.8 | 3.4 | 3.55 | 6.9 | 5.9 | 5.9 |
| 30 | 5.55 | ..... | 6.3 | 7.8 | 6.7 | 5.3 | 3.7 | 3.4 | 3.5 | 6.5 | 5.9 | 5.7 |
| 31 | 5.9 | ..... | 6.4 | ..... | 6.6 | ..... | 3.7 | 3.4 | ..... | 6.0 | ..... | 5.6 |

NOTE.—Gage heights November 12 to 17 were found by plotting several readings a day and taking the mean from the curve.

*Rating tables for Yakima River near Yakima, Wash.*

JANUARY 1, 1904, TO JUNE 4, 1905.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.80 | 920 | 4.70 | 1,800 | 5.60 | 3,070 | 6.50 | 5,035 | 7.80 | 9,170 |
| 3.90 | 1,000 | 4.80 | 1,920 | 5.70 | 3,240 | 6.60 | 5,295 | 8.00 | 9,930 |
| 4.00 | 1,090 | 4.90 | 2,045 | 5.80 | 3,420 | 6.70 | 5,565 | 8.20 | 10,740 |
| 4.10 | 1,180 | 5.00 | 2,180 | 5.90 | 3,615 | 6.80 | 5,835 | 8.40 | 11,600 |
| 4.20 | 1,280 | 5.10 | 2,315 | 6.00 | 3,830 | 6.90 | 6,115 | 8.60 | 12,480 |
| 4.30 | 1,380 | 5.20 | 2,455 | 6.10 | 4,055 | 7.00 | 6,405 | 8.80 | 13,360 |
| 4.40 | 1,480 | 5.30 | 2,600 | 6.20 | 4,285 | 7.20 | 7,025 | 9.00 | 14,240 |
| 4.50 | 1,580 | 5.40 | 2,750 | 6.30 | 4,525 | 7.40 | 7,720 | 9.20 | 15,120 |
| 4.60 | 1,690 | 5.50 | 2,910 | 6.40 | 4,775 | 7.60 | 8,440 | | |

JUNE 5, 1905, TO DECEMBER 31, 1906.[b]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3.00 | 460 | 4.10 | 1,290 | 5.20 | 2,840 | 6.60 | 6,220 | 8.80 | 14,670 |
| 3.10 | 500 | 4.20 | 1,405 | 5.30 | 3,020 | 6.80 | 6,890 | 9.00 | 15,600 |
| 3.20 | 550 | 4.30 | 1,520 | 5.40 | 3,210 | 7.00 | 7,590 | 10.00 | 20,800 |
| 3.30 | 605 | 4.40 | 1,640 | 5.50 | 3,400 | 7.20 | 8,290 | 11.00 | 26,700 |
| 3.40 | 665 | 4.50 | 1,760 | 5.60 | 3,600 | 7.40 | 9,010 | 12.00 | 33,200 |
| 3.50 | 725 | 4.60 | 1,890 | 5.70 | 3,810 | 7.60 | 9,750 | 13.00 | 40,500 |
| 3.60 | 795 | 4.70 | 2,030 | 5.80 | 4,030 | 7.80 | 10,510 | 14.00 | 48,600 |
| 3.70 | 875 | 4.80 | 2,180 | 5.90 | 4,260 | 8.00 | 11,300 | 15.00 | 57,400 |
| 3.80 | 965 | 4.90 | 2,340 | 6.00 | 4,500 | 8.20 | 12,100 | 16.00 | 67,000 |
| 3.90 | 1,070 | 5.00 | 2,500 | 6.20 | 5,030 | 8.40 | 12,930 | | |
| 4.00 | 1,180 | 5.10 | 2,670 | 6.40 | 5,600 | 8.60 | 13,780 | | |

[a] This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904–5 and is well defined.

[b] This table is applicable only for open-channel conditions. It is based on 12 discharge measurements made during 1905–6 and is well defined between gage heights 3.5 feet and 7.7 feet. The extension of the table is based on a discharge for the maximum gage height of 1906 computed from a measurement at Kiona.

*Monthly discharge of Yakima River near Yakima, Wash., for 1905–6.*

[Drainage area, 3,300 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| January | 2,180 | 1,280 | 1,830 | 113,000 | 0.554 | 0.64 |
| February | 3,620 | 920 | 1,750 | 95,900 | .523 | .54 |
| March | 9,550 | 3,830 | 7,540 | 463,000 | 2.28 | 2.63 |
| April | 9,930 | 3,420 | 4,750 | 283,000 | 1.44 | 1.61 |
| May | 7,720 | 3,830 | 4,930 | 303,000 | 1.49 | 1.72 |
| June | 14,700 | 5,310 | 8,320 | 495,000 | 2.52 | 2.81 |
| July | 5,900 | 1,290 | 2,710 | 167,000 | .821 | .95 |
| August | 1,290 | 795 | 922 | 56,700 | .279 | .32 |
| September | 1,180 | 795 | 904 | 53,800 | .274 | .31 |
| October | 5,750 | 1,290 | 3,200 | 197,000 | .970 | 1.12 |
| November | 2,670 | 1,520 | 1,880 | 112,000 | .570 | .64 |
| December | 2,100 | 1,400 | 1,700 | 105,000 | .515 | .59 |
| The year | 14,700 | 795 | 3,370 | 2,440,000 | 1.02 | 13.88 |
| 1906. | | | | | | |
| January | 4,260 | 1,180 | 1,820 | 112,000 | 0.552 | 0.64 |
| February | 5,030 | 2,500 | 3,880 | 215,000 | 1.18 | 1.23 |
| March | 5,600 | 2,670 | 3,480 | 214,000 | 1.05 | 1.21 |
| April | 13,800 | 7,590 | 9,900 | 589,000 | 3.00 | 3.35 |
| May | 12,100 | 4,260 | 7,910 | 486,000 | 2.40 | 2.77 |
| June | 7,240 | 3,020 | 4,410 | 262,000 | 1.34 | 1.50 |
| July | 3,810 | 965 | 1,970 | 121,000 | .600 | .69 |
| August | 795 | 635 | 694 | 42,700 | .210 | .24 |
| September | 760 | 635 | 705 | 42,000 | .212 | .24 |
| October | 8,650 | 725 | 2,220 | 136,000 | .673 | .78 |
| November | 63,900 | 2,180 | 12,400 | 738,000 | 3.76 | 4.20 |
| December | 6,550 | 2,500 | 3,920 | 241,000 | 1.19 | 1.37 |
| The year | 63,900 | 635 | 4,440 | 3,200,000 | 1.35 | 18.20 |

NOTE.—Values are rated as follows: 1905 and January to June, 1906, excellent; July to December, 1905, fair.

### YAKIMA RIVER AT PROSSER, WASH.

This station was established February 8, 1906, to replace the old station at the highway bridge below Prosser Falls, described in Water-Supply Paper No. 178, page 48. It was abandoned October 12, 1906, as it was found unsuited for low-water measurements and as the flow was controlled by dams above. It was located 1½ miles below the town of Prosser, about 1¼ miles below the county bridge across Yakima River and the power plant of the Prosser Falls Land and Power Company, and about 2,000 feet from the Northern Pacific Railroad tracks.

The channel is straight, and the current fairly swift except at low stages. The banks are of earth, intermingled with basaltic bowlders; the right bank is high; the left is low and liable to overflow at extreme high water. The bed of the stream is composed of massive bowlders and angular cobblestones. There is one channel at all stages.

Discharge measurements were made from a cable and car, which was removed when the station was abandoned. The initial point for soundings is a cross on a large bowlder, 2 feet back of the shear legs on the left bank.

A wooden inclined gage, which was read by G. W. Booth, was located on the right bank, 80 feet upstream from the shear legs. The bench mark is the top of a copper plug in a large bowlder about 40 feet downstream from the gage; elevation, 18.44 feet above the datum of the gage and 613.44 feet above sea level.

*Discharge measurements of Yakima River at Prosser, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 8 | W. C. Muldrow | 310 | 1,720 | 7.20 | 4,160 |
| February 23 | do | 312 | 1,990 | 8.04 | 5,450 |
| March 24 | J. C. Stevens | 303 | 1,610 | 6.84 | 3,200 |
| May 17 | W. C. Muldrow | 316 | 2,060 | 8.25 | 5,900 |
| July 12 | do | 291 | 1,160 | 5.48 | 1,470 |
| August 18 | J. C. Stevens | | | 3.00 | [a] 100 |
| November 17 [b] | D. C. Henny | 662 | 7,470 | | 62,800 |

[a] Estimated. [b] Measured by floats from new highway bridge above the dam.

*Daily gage height, in feet, of Yakima River at Prosser, Wash., for 1906.*

| Day. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.8 | 7.4 | 9.5 | 9.7 | 7.8 | 5.7 | 3.4 | 2.9 | 2.9 |
| 2 | 7.8 | 7.2 | 9.7 | 10.1 | 7.7 | 5.6 | 3.4 | 3.0 | 3.1 |
| 3 | 7.7 | 7.2 | 9.4 | 10.1 | 7.3 | 5.6 | 3.3 | 2.9 | 3.3 |
| 4 | 7.5 | 7.2 | 9.3 | 10.2 | 7.8 | 5.5 | 3.2 | 2.9 | 3.4 |
| 5 | 7.5 | 7.1 | 9.3 | 10.2 | 8.1 | 5.6 | 3.2 | 2.9 | 3.6 |
| 6 | 7.5 | 7.0 | 9.6 | 9.9 | 8.3 | 5.7 | 3.2 | 2.7 | 3.4 |
| 7 | 7.3 | 7.0 | 10.1 | 9.5 | 7.8 | 5.7 | 3.3 | 2.9 | 3.0 |
| 8 | 7.2 | 7.1 | 10.5 | 9.3 | 7.7 | 5.8 | 3.2 | 2.9 | 3.1 |
| 9 | 7.1 | 7.2 | 10.5 | 9.0 | 7.3 | 5.8 | 2.9 | 3.0 | 3.5 |
| 10 | 7.0 | 7.4 | 10.4 | 9.1 | 7.0 | 5.7 | 3.1 | 3.0 | 3.8 |
| 11 | 7.0 | 7.3 | 10.1 | 9.3 | 6.8 | 5.5 | 2.8 | 2.9 | 3.8 |
| 12 | 6.9 | 7.1 | 9.8 | 9.3 | 7.2 | 5.4 | 3.2 | 2.9 | 3.8 |
| 13 | 6.8 | 7.0 | 9.4 | 9.0 | 7.4 | 5.3 | 2.6 | 3.0 | ..... |
| 14 | 6.7 | 7.2 | 9.2 | 8.8 | 7.5 | 5.2 | 3.0 | 3.0 | ..... |
| 15 | 6.6 | 7.4 | 9.2 | 8.6 | 7.4 | 5.2 | 3.0 | 3.0 | ..... |
| 16 | 6.6 | 7.3 | 9.1 | 8.4 | 7.3 | 5.1 | 3.0 | 3.0 | ..... |
| 17 | 6.5 | 7.3 | 9.2 | 8.2 | 7.1 | 5.0 | 3.0 | 3.1 | ..... |
| 18 | 6.6 | 7.2 | 9.3 | 7.6 | 7.0 | 4.9 | 3.0 | 3.2 | ..... |
| 19 | 6.8 | 7.1 | 9.3 | 7.0 | 7.0 | 4.8 | 2.6 | 3.2 | ..... |
| 20 | 8.0 | 6.9 | 9.2 | 6.7 | 6.9 | 4.7 | 3.0 | 3.2 | ..... |
| 21 | 8.3 | 6.9 | 9.2 | 7.3 | 6.7 | 4.6 | 2.9 | 3.2 | ..... |
| 22 | 8.2 | 6.8 | 9.8 | 7.0 | 6.5 | 4.5 | 3.1 | 3.0 | ..... |
| 23 | 8.0 | 6.8 | 10.5 | 7.0 | 6.3 | 4.4 | 2.9 | 2.9 | ..... |
| 24 | 7.9 | 6.8 | 10.7 | 7.0 | 6.2 | 4.2 | 3.0 | 3.0 | ..... |
| 25 | 7.8 | 6.9 | 10.5 | 7.2 | 6.2 | 4.1 | 2.8 | 3.0 | ..... |
| 26 | 7.7 | 7.0 | 9.9 | 7.4 | 6.2 | 4.0 | 2.6 | 3.1 | ..... |
| 27 | 7.7 | 7.2 | 9.6 | 8.4 | 6.1 | 3.9 | 3.0 | 3.2 | ..... |
| 28 | 7.6 | 7.4 | 9.3 | 8.5 | 6.1 | 3.8 | 3.1 | 3.0 | ..... |
| 29 | ..... | 7.8 | 9.2 | 8.4 | 6.0 | 3.7 | 3.0 | 2.8 | ..... |
| 30 | ..... | 8.0 | 9.3 | 8.0 | 5.8 | 3.6 | 2.6 | 2.6 | ..... |
| 31 | ..... | 8.3 | ..... | 7.8 | ..... | 3.5 | 2.6 | ..... | ..... |

*Rating table for Yakima River at Prosser, Wash., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.60 | 40 | 3.80 | 345 | 5.00 | 1,060 | 6.40 | 2,580 | 8.80 | 7,050 |
| 2.70 | 50 | 3.90 | 390 | 5.10 | 1,140 | 6.60 | 2,860 | 9.00 | 7,510 |
| 2.80 | 65 | 4.00 | 435 | 5.20 | 1,225 | 6.80 | 3,160 | 9.20 | 7,980 |
| 2.90 | 80 | 4.10 | 485 | 5.30 | 1,310 | 7.00 | 3,480 | 9.40 | 8,460 |
| 3.00 | 100 | 4.20 | 540 | 5.40 | 1,400 | 7.20 | 3,820 | 9.60 | 8,940 |
| 3.10 | 120 | 4.30 | 595 | 5.50 | 1,500 | 7.40 | 4,170 | 9.80 | 9,440 |
| 3.20 | 145 | 4.40 | 655 | 5.60 | 1,600 | 7.60 | 4,530 | 10.00 | 9,940 |
| 3.30 | 170 | 4.50 | 715 | 5.70 | 1,710 | 7.80 | 4,910 | 11.00 | 12,500 |
| 3.40 | 200 | 4.60 | 780 | 5.80 | 1,820 | 8.00 | 5,310 | | |
| 3.50 | 230 | 4.70 | 845 | 5.90 | 1,940 | 8.20 | 5,730 | | |
| 3.60 | 265 | 4.80 | 915 | 6.00 | 2,060 | 8.40 | 6,160 | | |
| 3.70 | 305 | 4.90 | 985 | 6.20 | 2,310 | 8.60 | 6,600 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1906 and is well defined between gage heights 5 feet and 9 feet.

*Monthly discharge of Yakima River at Prosser, Wash., for 1906.*

[Drainage area, 5,050 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| February | 5,940 | 2,720 | 4,150 | 230,000 | 0.822 | 0.86 |
| March | 5,940 | 3,160 | 3,860 | 237,000 | .764 | .88 |
| April | 11,700 | 7,740 | 9,130 | 543,000 | 1.81 | 2.02 |
| May | 10,400 | 3,010 | 6,580 | 405,000 | 1.30 | 1.50 |
| June | 5,940 | 1,820 | 3,600 | 214,000 | .713 | .80 |
| July | 1,820 | 230 | 1,080 | 66,400 | .214 | .25 |
| August | 200 | 40 | 106 | 6,520 | .021 | .02 |
| September | 145 | 40 | 98.0 | 5,830 | .019 | .02 |
| October 1–12 | 345 | 80 | 210 | 5,000 | .042 | .02 |
| The period | ..... | ..... | ..... | 1,710,000 | ..... | ..... |

NOTE.—Values are rated as follows: February to June, excellent; July, good; August to October, fair.

### YAKIMA RIVER AT KIONA, WASH.

This station was established August 20, 1895. It is located at the highway bridge on the county road about 1,800 feet northwest of the Northern Pacific Railway station at Kiona, Wash. It is about 23 miles above the mouth of the river. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 49, where are given also references to publications that contain data for previous years.

The staff gage, installed December 23, 1905, was read from January 1 to March 22, 1906. Subsequent to that date the wire gage was used. These gages are referred to the following bench marks: (1) A standard U. S. Geological Survey iron bench-mark post near the Northern Pacific Railway station; elevation, 61.35 feet above the datum of the gage and 514.79 feet above mean sea level. (2) A standard U. S. Geological Survey iron bench mark in northeast corner of H. A. Shandy's lot near right approach of highway bridge; elevation, 18.99 feet above gage datum. These elevations were checked during 1906.

*Discharge measurements of Yakima River at Kiona, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 21 [a] | W. C. Muldrow | 265 | 1,580 | 7.14 | 5,480 |
| March 23 | J. C. Stevens | 275 | 1,200 | 5.72 | 2,870 |
| May 8 | W. C. Muldrow | 301 | 1,850 | 8.09 | 7,700 |
| July 11 | do | 217 | 925 | 4.64 | 1,560 |
| July 30 [b] | do | 67 | 82 | 2.99 | 309 |
| August 18 [b] | Muldrow and Stevens | 60 | 58 | 2.52 | 150 |
| October 13 [b] | W. C. Muldrow | 75 | 96 | 3.07 | 285 |
| November 17 [c] | D. C. Henny | 1,600 | 8,400 | 19.52 | 61,600 |
| November 19 [c] | W. C. Muldrow | | 4,250 | 15.00 | 31,700 |
| December 18 | do | 265 | 1,310 | 6.14 | 3,570 |

[a] Mean of two measurements. [b] Measured by wading. [c] Measured by floats.

*Daily gage height, in feet, of Yakima River at Kiona, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.55 | 6.35 | 6.35 | 8.5 | 8.7 | 6.8 | 4.8 | 2.8 | 2.45 | 2.75 | 5.8 | 6.55 |
| 2 | 4.55 | 6.45 | 6.25 | 8.8 | 9.2 | 6.7 | 4.8 | 2.8 | 2.4 | 2.8 | 5.7 | 6.55 |
| 3 | 4.55 | 6.65 | 6.15 | 8.6 | 9.4 | 6.5 | 4.7 | 2.7 | 2.45 | 2.85 | 5.5 | 6.55 |
| 4 | 4.55 | 6.55 | 6.05 | 8.45 | 9.45 | 6.7 | 4.7 | 2.7 | 2.4 | 2.9 | 5.4 | 6.6 |
| 5 | 4.6 | 6.45 | 6.05 | 8.4 | 9.4 | 6.9 | 4.7 | 2.7 | 2.4 | 2.95 | 5.3 | 6.7 |
| 6 | 4.6 | 6.35 | 6.0 | 8.8 | 9.3 | 7.2 | 4.7 | 2.7 | 2.45 | 3.0 | 5.2 | 6.7 |
| 7 | 4.6 | 6.25 | 5.95 | 9.3 | 8.8 | 6.9 | 4.7 | 2.7 | 2.45 | 3.0 | 5.2 | 6.7 |
| 8 | 4.6 | 6.15 | 5.95 | 9.7 | 8.5 | 6.8 | 4.6 | 2.65 | 2.5 | 3.0 | 5.5 | 6.7 |
| 9 | 4.65 | 6.15 | 6.45 | 9.8 | 8.3 | 6.4 | 4.6 | 2.6 | 2.45 | 3.1 | 5.3 | 6.7 |
| 10 | 4.65 | 6.05 | 6.55 | 9.75 | 8.3 | 6.3 | 4.6 | 2.6 | 2.4 | 3.2 | 5.7 | 6.7 |
| 11 | 4.65 | 5.95 | 6.65 | 9.35 | 8.3 | 6.2 | 4.45 | 2.6 | 2.35 | 3.2 | 6.2 | 6.65 |
| 12 | 4.65 | 5.9 | 6.45 | 9.05 | 8.4 | 6.1 | 4.35 | 2.55 | 2.4 | 3.1 | 6.82 | 6.6 |
| 13 | 4.6 | 5.75 | 6.25 | 8.6 | 8.2 | 6.3 | 4.25 | 2.6 | 2.5 | 3.05 | 7.90 | 6.5 |
| 14 | 4.6 | 5.6 | 6.05 | 9.4 | 7.9 | 6.3 | 4.2 | 2.6 | 2.55 | 3.05 | 10.4 | 6.4 |
| 15 | 4.6 | 5.55 | 6.25 | 9.2 | 7.6 | 6.3 | 4.1 | 2.5 | 2.55 | 3.05 | 13.02 | 6.3 |
| 16 | 4.55 | 5.5 | 6.45 | 8.1 | 7.55 | 6.2 | 4.0 | 2.45 | 2.6 | 3.1 | 17.34 | 6.3 |
| 17 | 4.55 | 5.45 | 6.35 | 8.3 | 7.25 | 6.2 | 3.9 | 2.5 | 2.6 | 3.1 | 19.78 | 6.2 |
| 18 | 4.55 | 5.45 | 6.25 | 8.4 | 6.95 | 6.1 | 3.8 | 2.45 | 2.55 | 3.3 | 17.55 | 6.15 |
| 19 | 4.5 | 5.65 | 6.05 | 8.4 | 6.55 | 6.0 | 3.7 | 2.5 | 2.5 | 3.8 | 15.62 | 6.2 |
| 20 | 4.45 | 6.65 | 5.85 | 8.45 | 6.3 | 5.8 | 3.6 | 2.45 | 2.55 | 4.1 | 12.84 | 6.3 |

*Daily gage height, in feet, of Yakima River at Kiona, Wash., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 4.4 | 7.35 | 5.9 | 8.5 | 6.2 | 5.7 | 3.5 | 2.5 | 2.6 | 4.3 | 10.62 | 6.3 |
| 22 | 4.5 | 7.2 | 5.95 | 8.7 | 6.05 | 5.5 | 3.3 | 2.45 | 2.6 | 4.3 | 9.9 | 6.9 |
| 23 | 4.65 | 7.1 | 5.95 | 9.6 | 6.0 | 5.4 | 3.2 | 2.5 | 2.65 | 4.3 | 8.9 | 8.3 |
| 24 | 4.85 | 7.0 | 5.85 | 9.9 | 5.9 | 5.2 | 3.1 | 2.5 | 2.65 | 4.2 | 8.5 | 8.3 |
| 25 | 4.75 | 6.75 | 5.9 | 9.7 | 5.8 | 5.2 | 3.1 | 2.55 | 2.68 | 4.2 | 8.2 | 8.2 |
| 26 | 5.75 | 6.65 | 5.9 | 9.2 | 6.2 | 5.2 | 3.0 | 2.55 | 2.7 | 4.1 | 8.0 | 8.05 |
| 27 | 5.85 | 6.45 | 6.0 | 9.0 | 7.25 | 5.1 | 2.8 | 2.55 | 2.7 | 4.3 | 7.7 | 8.05 |
| 28 | 6.25 | 6.45 | 6.35 | 8.5 | 7.5 | 5.0 | 2.8 | 2.5 | 2.7 | 7.2 | 7.5 | 7.7 |
| 29 | 6.3 | ..... | 6.55 | 8.4 | 7.4 | 4.9 | 2.8 | 2.55 | 2.7 | 7.0 | 7.1 | 7.6 |
| 30 | 6.35 | ..... | 6.9 | 8.5 | 7.1 | 4.8 | 2.75 | 2.5 | 2.7 | 6.7 | 6.9 | 7.3 |
| 31 | 6.25 | ..... | 7.3 | ..... | 7.0 | ..... | 2.8 | 2.4 | ..... | 6.5 | ..... | 7.3 |

NOTE.—The gage heights from November 15 to 21 were found by plotting several readings a day, and taking the mean from the curve.

*Rating table for Yakima River at Kiona, Wash., from October 1, 1905, to December 31, 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.30 | 90 | 3.60 | 620 | 4.90 | 1,780 | 6.40 | 3,990 | 9.00 | 9,590 |
| 2.40 | 120 | 3.70 | 690 | 5.00 | 1,900 | 6.60 | 4,350 | 10.00 | 12,100 |
| 2.50 | 150 | 3.80 | 760 | 5.10 | 2,020 | 6.80 | 4,740 | 11.00 | 14,950 |
| 2.60 | 180 | 3.90 | 835 | 5.20 | 2,150 | 7.00 | 5,140 | 12.00 | 18,150 |
| 2.70 | 210 | 4.00 | 910 | 5.30 | 2,280 | 7.20 | 5,550 | 13.00 | 21,900 |
| 2.80 | 245 | 4.10 | 990 | 5.40 | 2,420 | 7.40 | 5,970 | 14.00 | 26,350 |
| 2.90 | 280 | 4.20 | 1,070 | 5.50 | 2,560 | 7.60 | 6,390 | 15.00 | 31,700 |
| 3.00 | 315 | 4.30 | 1,160 | 5.60 | 2,700 | 7.80 | 6,830 | 16.00 | 37,600 |
| 3.10 | 355 | 4.40 | 1,250 | 5.70 | 2,850 | 8.00 | 7,270 | 17.00 | 44,000 |
| 3.20 | 400 | 4.50 | 1,350 | 5.80 | 3,000 | 8.20 | 7,710 | 18.00 | 50,800 |
| 3.30 | 450 | 4.60 | 1,450 | 5.90 | 3,160 | 8.40 | 8,170 | 19.00 | 57,800 |
| 3.40 | 500 | 4.70 | 1,560 | 6.00 | 3,320 | 8.60 | 8,630 | 20.00 | 65,100 |
| 3.50 | 555 | 4.80 | 1,670 | 6.20 | 3,650 | 8.80 | 9,110 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1897–1905 and is well defined.

*Monthly discharge of Yakima River at Kiona, Wash., for 1905–6.*

[Drainage area, 5,230 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| October[a] | 4,740 | 690 | 2,470 | 152,000 | 0.473 | 0.56 |
| November[a] | 2,560 | 1,560 | 1,860 | 111,000 | .356 | .44 |
| December[a] | 1,900 | 1,450 | 1,710 | 105,000 | .327 | .44 |
| 1906. | | | | | | |
| January | 3,900 | 1,250 | 1,850 | 114,000 | .354 | .41 |
| February | 5,860 | 2,490 | 3,840 | 213,000 | .734 | .76 |
| March | 5,760 | 3,080 | 3,710 | 228,000 | .709 | .82 |
| April | 11,800 | 7,490 | 9,400 | 559,000 | 1.80 | 2.01 |
| May | 10,700 | 3,000 | 6,620 | 407,000 | 1.27 | 1.46 |
| June | 5,550 | 1,670 | 3,440 | 205,000 | .658 | .73 |
| July | 1,670 | 228 | 923 | 56,800 | .176 | .20 |
| August | 245 | 120 | 172 | 10,600 | .033 | .04 |
| September | 210 | 105 | 162 | 9,640 | .031 | .03 |
| October | 5,550 | 228 | 1,120 | 68,900 | .214 | .25 |
| November | 63,500 | 2,150 | 12,400 | 738,000 | 2.37 | 2.64 |
| December | 7,940 | 3,560 | 5,010 | 308,000 | .958 | 1.10 |
| The year | 63,500 | 105 | 4,050 | 2,920,000 | .776 | 10.45 |

[a] These values supersede those published in Water-Supply Paper No. 178, which were in error. The published gage heights for 1905 were in error as follows: October 21 to November 9, 0.7 foot too high; November 10 to 29, 0.2 foot too high; November 30 to December 19, 0.3 foot too high, and from December 19 to 23, 0.35 foot too high.

NOTE.—Values for 1905 and 1906 are rated as good.

## YAKIMA RIVER NEAR RICHLAND, WASH.

This station was established July 28, 1906, for the purpose of determining the amount of water wasted into Columbia River. It is maintained only during the irrigating season. It is located at Yakima Ferry, near the mouth of Yakima River, and below the headgate of the Amon Canal, the last diversion.

The channel is straight, the banks are high and clean. The bed of the stream is composed of gravel and bowlders.

Measurements are made by wading at any convenient place near the gage.

The gage, which was read during the season by J. E. See, is a 1 by 6 inch board bolted to a large bowlder in midstream, 500 feet below the ferry. The bench mark is a cross, marked B. M., on a large, round bowlder in the channel, at right angles to the direction of current from the old cribworks on the right bank, where an old water lift wheel was located; elevation, 5.05 feet above the datum of the gage.

*Discharge measurements of Yakima River near Richland, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| July 28 | W. C. Muldrow | 89 | 122 | 1.46 | 175 |
| August 17 | J. C. Stevens | 16 | 12 | .63 | 9.4 |
| October 13 | W. C. Muldrow | 100 | 140 | 1.55 | 195 |

*Daily gage height, in feet, of Yakima River near Richland, Wash., for 1906.*

| Day. | July. | Aug. | Sept. | Oct. | Day. | July. | Aug. | Sept. | Oct. | Day. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1.25 | 0.6 | 0.8 | 12 | | 0.7 | 0.6 | 1.6 | 23 | | 0.6 | 0.6 | |
| 2 | | 1.15 | .6 | .85 | 13 | | .7 | .6 | 1.55 | 24 | | .6 | .6 | |
| 3 | | 1.1 | .6 | 1.0 | 14 | | .65 | .6 | 1.52 | 25 | | .6 | .75 | |
| 4 | | 1.5 | .6 | 1.25 | 15 | | .65 | .6 | 1.6 | 26 | | .6 | .8 | |
| 5 | | 1.0 | .6 | 1.2 | 16 | | .65 | .6 | 1.7 | 27 | | .6 | .88 | |
| 6 | | 0.9 | .6 | 1.35 | 17 | | .65 | .6 | 1.75 | 28 | 1.5 | .6 | .8 | |
| 7 | | .8 | .6 | 1.3 | 18 | | .6 | .6 | 1.78 | 29 | 1.4 | .6 | .8 | |
| 8 | | .75 | .6 | 1.38 | 19 | | .6 | .6 | 1.9 | 30 | 1.35 | .6 | .8 | |
| 9 | | .7 | .6 | 1.28 | 20 | | .6 | .6 | 2.8 | 31 | 1.25 | .6 | | |
| 10 | | .75 | .6 | 1.5 | 21 | | .6 | .6 | | | | | | |
| 11 | | .7 | .6 | 1.55 | 22 | | .6 | .6 | | | | | | |

*Rating table for Yakima River near Richland, Wash., from July 28, 1906, to October 19, 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.60 | 8 | 0.90 | 31 | 1.20 | 87 | 1.50 | 185 | 1.80 | 340 |
| 0.70 | 13 | 1.00 | 46 | 1.30 | 114 | 1.60 | 235 | 1.90 | 400 |
| 0.80 | 21 | 1.10 | 65 | 1.40 | 145 | 1.70 | 280 | | |

NOTE.—The above table is based on 3 discharge measurements made during 1906 and is not well defined.

*Monthly discharge of Yakima River near Richland, Wash., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| July (28–31) | 185 | 100 | 140 | 1,110 |
| August | 185 | 8 | 24.6 | 1,510 |
| September | 29 | 8 | 10.7 | 637 |
| October (1–19) | 400 | 21 | 178 | 6,710 |
| The period | | | | 9,970 |

NOTE.—Values are rated as fair.

## LAKE KEECHELUS NEAR MARTIN, WASH.

This station was established January 12, 1906, to obtain the fluctuations of the lake surface and the amount of stored water. It is located at the foot of the lake, 4 miles northeast of Martin, Wash., on the State road over Snoqualmie Pass.

All gage heights for 1906 refer to the level of the sill of the outlet tunnel of the dam, which is 2,457.00 feet above sea level. The bench mark is a spike in the root of a stump on the right bank of the outlet near the abutment of the dam; elevation, 16.05 feet above the datum of the gage and 2,473.05 above sea level.

*Daily gage height, in feet, of Lake Keechelus near Martin, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1.72 | 1.48 | 1.73 | 3.17 | 2.47 | 1.73 | 0.82 | 0.40 | 0.44 | 2.22 | 3.12 |
| 2 | | 1.62 | 1.41 | 1.86 | 3.57 | 2.40 | 1.73 | .80 | .38 | .36 | 2.06 | 3.31 |
| 3 | | 1.53 | 1.33 | 1.84 | 3.54 | 2.40 | 1.73 | .78 | .37 | .54 | 2.02 | 3.41 |
| 4 | | 1.43 | 1.28 | 1.84 | 3.50 | 2.63 | 1.70 | .78 | .36 | .91 | 1.99 | 3.59 |
| 5 | | 1.35 | 1.25 | 1.91 | 3.39 | 2.58 | 1.68 | .76 | .35 | .93 | 1.94 | 3.85 |
| 6 | | 1.32 | 1.20 | 2.10 | 3.16 | 2.51 | 1.64 | .75 | .32 | .92 | 2.08 | 4.12 |
| 7 | | 1.31 | 1.16 | 2.37 | 3.02 | 2.44 | 1.58 | .75 | .36 | .88 | 2.22 | 4.59 |
| 8 | | 1.30 | 1.16 | 2.53 | 2.96 | 2.34 | 1.52 | .74 | .36 | .94 | 2.44 | 4.82 |
| 9 | | 1.28 | 1.22 | 2.58 | 3.03 | 2.24 | 1.47 | .73 | .36 | .99 | 2.64 | 5.01 |
| 10 | | 1.26 | 1.30 | 2.53 | 3.25 | 2.19 | 1.44 | .72 | .36 | 1.00 | 3.16 | 5.09 |
| 11 | | 1.24 | 1.33 | 2.42 | 3.30 | 2.15 | 1.43 | .70 | .33 | .97 | 3.70 | 5.20 |
| 12 | 0.86 | 1.22 | 1.36 | 2.30 | 3.28 | 2.22 | 1.37 | .70 | .32 | 1.01 | 3.92 | 4.66 |
| 13 | .85 | 1.20 | 1.34 | 2.16 | 3.09 | 2.17 | 1.34 | .69 | .32 | 1.04 | 5.73 | 4.21 |
| 14 | .83 | 1.18 | 1.32 | 2.06 | 2.90 | 2.14 | 1.31 | .64 | .52 | 1.10 | 6.09 | 4.01 |
| 15 | .77 | 1.16 | 1.28 | 2.04 | 2.95 | 2.11 | 1.26 | .64 | .54 | 1.32 | ..... | 3.93 |
| 16 | .92 | 1.16 | 1.24 | 2.00 | 2.84 | 2.08 | 1.24 | .63 | .52 | 1.67 | ..... | 3.81 |
| 17 | .94 | 1.17 | 1.24 | 2.25 | 2.73 | 2.03 | 1.21 | .62 | .50 | 2.22 | ..... | 4.03 |
| 18 | 1.00 | 1.20 | 1.18 | 2.32 | 2.56 | 2.00 | 1.17 | .62 | .46 | 2.64 | ..... | 4.01 |
| 19 | | 1.70 | 1.18 | 2.34 | 2.43 | 1.96 | 1.13 | .61 | .42 | 2.64 | ..... | 4.41 |
| 20 | | 1.84 | 1.13 | 2.46 | 2.36 | 1.94 | 1.10 | .60 | .40 | 2.50 | ..... | 4.91 |
| 21 | 1.46 | 1.87 | 1.10 | 2.76 | 2.30 | 1.94 | 1.06 | .60 | .37 | 2.27 | ..... | 4.95 |
| 22 | 1.57 | 1.86 | 1.08 | 3.04 | 2.28 | 1.99 | 1.04 | .58 | .35 | 2.16 | ..... | 4.75 |
| 23 | 1.77 | 1.84 | 1.08 | 3.07 | 2.21 | 1.96 | 1.02 | .56 | .34 | 2.11 | ..... | 4.52 |
| 24 | 1.84 | 1.84 | 1.04 | 2.98 | 2.17 | 1.92 | .97 | .54 | .34 | 2.06 | ..... | 4.31 |
| 25 | 1.87 | 1.80 | 1.02 | 2.92 | 2.26 | 1.90 | .94 | .52 | .40 | 2.17 | ..... | 4.29 |
| 26 | 2.00 | 1.75 | 1.04 | 2.88 | 2.65 | 1.86 | .92 | .50 | .47 | 2.27 | ..... | 4.69 |
| 27 | 2.20 | 1.67 | 1.08 | 2.82 | 2.69 | 1.86 | .90 | .49 | .48 | 2.32 | ..... | 5.02 |
| 28 | 2.14 | 1.58 | 1.11 | 2.80 | 2.62 | 1.83 | .88 | .48 | .50 | 2.47 | ..... | 5.32 |
| 29 | 2.03 | ..... | 1.16 | 2.90 | 2.53 | 1.84 | .86 | .46 | .48 | 2.67 | ..... | 5.63 |
| 30 | 1.93 | ..... | 1.25 | 3.02 | 2.56 | 1.82 | .85 | .43 | .45 | 2.57 | 3.12 | 5.95 |
| 31 | 1.82 | ..... | 1.56 | ..... | 2.52 | ..... | .84 | .41 | ..... | 2.37 | ..... | 6.22 |

## KACHESS LAKE NEAR EASTON, WASH.

This station was established September 20, 1905, in order to determine the amount of storage in Kachess Lake. The datum of the gage is the same as during 1905.

*Daily gage height, in feet, of Kachess Lake, near Easton, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.25 | 2.2 | 1.95 | 1.7 | 3.6 | 5.6 | 5.4 | 3.25 | 1.35 | 0.55 | 2.45 | 3.85 |
| 2 | 1.2 | 2.2 | 1.9 | 1.8 | 3.8 | 5.65 | 5.3 | 3.2 | 1.3 | .6 | 2.35 | 3.6 |
| 3 | 1.15 | 2.15 | 1.85 | 1.9 | 3.8 | 5.8 | 5.25 | 3.2 | 1.2 | .6 | 2.3 | 3.35 |
| 4 | 1.2 | 2.15 | 1.8 | 2.0 | 3.8 | 6.0 | 5.2 | 3.15 | 1.1 | .65 | 2.2 | 3.2 |
| 5 | 1.15 | 2.15 | 1.8 | 2.0 | 3.75 | 6.05 | 5.1 | 3.15 | 1.1 | .65 | 2.2 | 3.0 |
| 6 | 1.25 | 2.1 | 1.7 | 2.1 | 3.7 | 6.1 | 5.05 | 3.15 | 1.0 | .65 | 2.4 | 2.85 |
| 7 | 1.15 | 2.05 | 1.6 | 2.25 | 3.6 | 6.1 | 5.0 | 3.1 | 1.0 | .65 | 2.5 | 2.9 |
| 8 | 1.15 | 2.05 | 1.6 | 2.5 | 3.5 | 6.05 | 4.9 | 3.1 | .95 | .65 | 2.65 | 2.8 |
| 9 | 1.2 | 2.0 | 1.6 | 2.65 | 3.5 | 6.0 | 4.8 | 3.05 | .9 | .6 | 2.75 | 2.6 |
| 10 | 1.15 | 2.0 | 1.6 | 2.7 | 3.6 | 6.0 | 4.7 | 3.0 | .85 | .65 | 3.1 | 2.5 |
| 11 | 1.1 | 2.05 | 1.6 | 2.7 | 3.8 | 5.95 | 4.6 | 2.9 | .8 | .65 | 3.4 | 2.4 |
| 12 | 1.1 | 1.95 | 1.6 | 2.6 | 4.0 | 5.95 | 4.5 | 2.85 | .75 | .65 | 3.92 | 2.3 |
| 13 | 1.15 | 1.9 | 1.6 | 2.6 | 4.1 | 5.9 | 4.45 | 2.75 | .75 | .65 | 5.38 | 2.2 |
| 14 | 1.15 | 1.9 | 1.6 | 2.6 | 4.2 | 5.9 | 4.35 | 2.7 | .8 | .7 | 8.18 | 2.15 |
| 15 | 1.15 | 1.8 | 1.55 | 2.6 | 4.4 | 5.85 | 4.25 | 2.65 | .75 | .75 | 9.46 | 2.1 |
| 16 | 1.1 | 1.7 | 1.55 | 2.65 | 4.6 | 5.85 | 4.2 | 2.55 | .7 | .85 | 9.34 | 2.05 |
| 17 | 1.1 | 1.7 | 1.55 | 2.7 | 4.7 | 5.75 | 4.1 | 2.5 | .7 | 1.1 | 8.72 | 1.95 |
| 18 | 1.1 | 1.85 | 1.55 | 2.7 | 4.8 | 5.7 | 4.0 | 2.4 | .7 | 1.25 | 8.1 | 1.9 |
| 19 | 1.1 | 1.9 | 1.55 | 2.8 | 5.0 | 5.7 | 3.9 | 2.3 | .65 | 1.3 | 7.6 | 2.0 |
| 20 | 1.1 | 1.95 | 1.5 | 2.8 | 5.15 | 5.7 | 3.8 | 2.2 | .6 | 1.3 | 7.1 | 2.15 |
| 21 | 1.15 | 1.9 | 1.5 | 3.0 | 5.25 | 5.75 | 3.7 | 2.1 | .6 | 1.3 | 6.6 | 2.2 |
| 22 | 1.15 | 2.0 | 1.5 | 3.3 | 5.35 | 5.8 | 3.6 | 2.05 | .6 | 1.3 | 6.2 | 2.25 |
| 23 | 1.3 | 1.9 | 1.4 | 3.4 | 5.4 | 5.8 | 3.5 | 2.0 | .6 | 1.25 | 5.8 | 2.2 |
| 24 | 1.35 | 1.85 | 1.4 | 3.5 | 5.45 | 5.8 | 3.5 | 1.9 | .55 | 1.3 | 5.4 | 2.15 |
| 25 | 1.45 | 1.95 | 1.5 | 3.5 | 5.45 | 5.8 | 3.4 | 1.9 | .6 | 1.4 | 5.3 | 2.1 |
| 26 | 1.65 | 2.0 | 1.4 | 3.5 | 5.45 | 5.75 | 3.4 | 1.8 | .55 | 2.3 | 4.9 | 2.1 |
| 27 | 1.7 | 1.95 | 1.4 | 3.5 | 5.5 | 5.65 | 3.35 | 1.7 | .6 | 2.7 | 4.5 | 2.1 |
| 28 | 1.9 | 1.95 | 1.4 | 3.5 | 5.5 | 5.6 | 3.3 | 1.7 | .6 | 2.7 | 4.4 | 2.05 |
| 29 | 2.0 | ..... | 1.5 | 3.5 | 5.55 | 5.5 | 3.3 | 1.6 | .55 | 2.6 | 4.2 | 2.0 |
| 30 | 2.15 | ..... | 1.5 | 3.55 | 5.55 | 5.45 | 3.3 | 1.5 | .5 | 2.6 | 4.0 | 1.95 |
| 31 | 2.15 | ..... | 1.5 | ..... | 5.5 | ..... | 3.3 | 1.45 | ..... | 2.45 | ..... | 1.9 |

## KACHESS RIVER NEAR EASTON, WASH.

This station was established October 14, 1903. It is located 2 miles northwest of Easton, Wash., and one-half mile below the foot of Lake Kachess, at the outlet of which a dam has been constructed by the Cascade Canal Company. This dam controls the flow. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 78, where are given also references to publications that contain data for previous years.

*Discharge measurements of Kachess River near Easton, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 16 | J. C. Stevens | 70 | 113 | 3.86 | 215 |
| May 1 | W. C. Muldrow | 76 | 229 | 5.45 | 732 |
| July 16 | do | 69 | 120 | 4.01 | 256 |
| August 11 | do | 68 | 94 | 3.62 | 156 |
| August 23 | do | 68 | 97 | 3.63 | 149 |
| September 24 | do | 64 | 67 | 3.23 | 74 |
| October 29 | Muldrow and McGlashan | 74 | 164 | 4.60 | 428 |
| November 26 | W. C. Muldrow | 76 | 230 | 5.50 | 722 |

*Daily gage height, in feet, of Kachess River near Easton, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.7 | 4.2 | 4.1 | 3.95 | 5.45 | 3.95 | 4.25 | 3.3 | 3.55 | 3.2 | 4.4 | 5.1 |
| 2 | 3.65 | 4.2 | 4.0 | 4.0 | 5.5 | 3.9 | 4.2 | 3.3 | 3.6 | 3.25 | 4.3 | 5.0 |
| 3 | 3.65 | 4.2 | 4.0 | 4.05 | 5.5 | 4.0 | 4.15 | 3.25 | 3.6 | 3.3 | 4.2 | 4.9 |
| 4 | 3.65 | 4.15 | 4.0 | 4.1 | 5.5 | 4.1 | 4.2 | 3.2 | 3.6 | 3.35 | 4.0 | 4.9 |
| 5 | 3.65 | 4.2 | 4.0 | 4.1 | 5.45 | 4.2 | 4.2 | 3.2 | 3.55 | 3.35 | 3.2 | 4.8 |
| 6 | 3.7 | 4.15 | 3.9 | 4.2 | 5.4 | 4.3 | 4.25 | 3.2 | 3.5 | 3.35 | 3.2 | 4.6 |
| 7 | 3.65 | 4.15 | 3.9 | 4.35 | 5.4 | 4.3 | 4.3 | 3.2 | 3.5 | 3.35 | 3.3 | 4.6 |
| 8 | 3.65 | 4.15 | 3.9 | 4.45 | 5.3 | 4.25 | 4.2 | 3.25 | 3.5 | 3.3 | 3.3 | 4.5 |
| 9 | 3.7 | 4.1 | 3.9 | 4.55 | 5.3 | 4.6 | 4.15 | 3.6 | 3.45 | 3.3 | 3.35 | 4.45 |
| 10 | 3.6 | 4.1 | 3.9 | 4.6 | 5.4 | 4.6 | 4.1 | 3.65 | 3.45 | 3.3 | 3.4 | 4.4 |
| 11 | 3.6 | 4.1 | 3.9 | 4.55 | 4.5 | 4.6 | 4.05 | 3.6 | 3.4 | 3.3 | 3.45 | 4.35 |
| 12 | 3.6 | 4.1 | 3.9 | 4.5 | 4.25 | 4.55 | 4.0 | 3.6 | 3.4 | 3.3 | 3.72 | 4.35 |
| 13 | 3.6 | 4.05 | 3.9 | 4.5 | 4.2 | 4.55 | 4.0 | 3.6 | 3.35 | 3.3 | 4.68 | 4.3 |
| 14 | 3.6 | 4.0 | 3.9 | 4.5 | 3.7 | 4.5 | 4.1 | 3.6 | 3.35 | 3.35 | 6.64 | 4.2 |
| 15 | 3.6 | 3.95 | 3.9 | 4.5 | 3.7 | 4.5 | 4.05 | 3.6 | 3.35 | 3.4 | 7.85 | 4.15 |
| 16 | 3.6 | 3.9 | 3.9 | 4.55 | 3.8 | 4.45 | 4.0 | 3.65 | 3.3 | 3.45 | 8.0 | 4.1 |
| 17 | 3.6 | 3.9 | 3.9 | 4.6 | 3.7 | 4.45 | 4.0 | 3.65 | 3.3 | 3.55 | 7.82 | 4.1 |
| 18 | 3.6 | 3.95 | 3.85 | 4.6 | 3.65 | 4.4 | 3.95 | 3.75 | 3.3 | 3.65 | 7.5 | 4.05 |
| 19 | 3.6 | 4.0 | 3.85 | 4.65 | 3.6 | 4.1 | 3.85 | 3.75 | 3.3 | 3.7 | 7.2 | 4.05 |
| 20 | 3.6 | 4.05 | 3.8 | 4.65 | 3.6 | 4.1 | 3.8 | 3.7 | 3.25 | 3.7 | 6.8 | 4.1 |
| 21 | 3.65 | 4.05 | 3.8 | 4.8 | 3.65 | 4.0 | 3.85 | 3.7 | 3.25 | 3.7 | 6.6 | 4.15 |
| 22 | 3.65 | 4.15 | 3.8 | 5.0 | 3.65 | 3.95 | 3.8 | 3.65 | 3.25 | 3.7 | 6.4 | 4.25 |
| 23 | 3.7 | 4.1 | 3.75 | 5.05 | 3.6 | 3.9 | 3.7 | 3.7 | 3.2 | 3.65 | 6.1 | 4.2 |
| 24 | 3.8 | 4.1 | 3.75 | 5.15 | 3.6 | 3.9 | 3.4 | 3.6 | 3.2 | 3.65 | 5.85 | 4.2 |
| 25 | 3.85 | 4.1 | 3.8 | 5.2 | 4.2 | 4.5 | 3.3 | 3.7 | 3.3 | 3.7 | 5.7 | 4.15 |
| 26 | 4.0 | 4.15 | 3.75 | 5.2 | 4.55 | 4.55 | 3.35 | 3.7 | 3.25 | 4.45 | 5.5 | 4.15 |
| 27 | 4.0 | 4.1 | 3.75 | 5.2 | 4.55 | 4.55 | 3.45 | 3.65 | 3.25 | 4.8 | 5.3 | 4.15 |
| 28 | 4.1 | 4.1 | 3.75 | 5.2 | 4.6 | 4.5 | 3.35 | 3.6 | 3.25 | 4.7 | 5.3 | 4.1 |
| 29 | 4.1 | ..... | 3.8 | 5.3 | 4.6 | 4.5 | 3.3 | 3.7 | 3.2 | 4.6 | 5.2 | 4.1 |
| 30 | 4.1 | ..... | 3.8 | 5.4 | 4.6 | 4.35 | 3.25 | 3.65 | 3.2 | 4.6 | 5.15 | 4.05 |
| 31 | 4.15 | ..... | 3.81 | ..... | 4.55 | ..... | 3.3 | 3.6 | ..... | 4.4 | ..... | 4.0 |

NOTE.—Gage heights for November 12 to 17 were found by plotting several readings a day and taking the mean from the curve.

*Rating table for Kachess River near Easton, Wash., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.20 | 62 | 4.00 | 240 | 4.80 | 475 | 5.60 | 780 | 6.80 | 1,440 |
| 3.30 | 80 | 4.10 | 266 | 4.90 | 510 | 5.70 | 830 | 7.00 | 1,560 |
| 3.40 | 98 | 4.20 | 294 | 5.00 | 545 | 5.80 | 880 | 7.20 | 1,690 |
| 3.50 | 118 | 4.30 | 322 | 5.10 | 580 | 5.90 | 930 | 7.40 | 1,830 |
| 3.60 | 140 | 4.40 | 350 | 5.20 | 615 | 6.00 | 980 | 7.60 | 1,980 |
| 3.70 | 164 | 4.50 | 380 | 5.30 | 655 | 6.20 | 1,090 | 7.80 | 2,140 |
| 3.80 | 188 | 4.60 | 410 | 5.40 | 695 | 6.40 | 1,200 | 8.00 | 2,300 |
| 3.90 | 214 | 4.70 | 442 | 5.50 | 735 | 6.60 | 1,320 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1906 and is well defined below gage height 5.5 feet.

*Monthly discharge of Kachess River near Easton, Wash., for 1906.*

[Drainage area, 63 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 280 | 140 | 173 | 10,600 | 2.75 | 3.17 |
| February | 294 | 214 | 263 | 14,600 | 4.17 | 4.34 |
| March | 266 | 176 | 206 | 12,700 | 3.27 | 3.77 |
| April | 695 | 227 | 434 | 25,800 | 6.89 | 7.69 |
| May | 735 | 140 | 401 | 24,700 | 6.37 | 7.34 |
| June | 410 | 214 | 325 | 19,300 | 5.16 | 5.76 |
| July | 322 | 71 | 211 | 13,000 | 3.35 | 3.86 |
| August | 176 | 62 | 131 | 8,060 | 2.08 | 2.40 |
| September | 140 | 62 | 92.8 | 5,520 | 1.47 | 1.64 |
| October | 475 | 62 | 168 | 10,300 | 2.67 | 3.08 |
| November | 2,300 | 62 | 798 | 47,500 | 12.67 | 14.14 |
| December | 580 | 240 | 337 | 20,700 | 5.35 | 6.17 |
| The year | 2,300 | 62 | 295 | 213,000 | 4.68 | 63.36 |

NOTE.—Values are rated as follows: January to March and July to October, good; remainder of year, excellent.

### CLEALUM RIVER NEAR ROSLYN, WASH.

This station was established October 10, 1903. It is located 1,000 feet below the outlet of Lake Clealum. It is 2½ miles northwest of Roslyn and 6½ miles northwest of Clealum, Wash. On March 17, 1906, the gage was lowered to the same datum as was used prior to August 28, 1905. All gage heights of 1906 refer to this datum, 17.40 feet below the bench mark, which is a large spike driven into a root on the downstream side of the blazed tree on the left bank to which the cable is fastened. The gage was read during 1906 by Mark Barkwell, Mrs. Samuel Davis, and employees of the United States Reclamation Service . The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 80, where are given also references to publications that contain data for previous years.

*Discharge measurements of Clealum River near Roslyn, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 17[a] | J. C. Stevens | 124 | 720 | 2.35 | 526 |
| May 3 | W. C. Muldrow | 148 | 1,220 | 5.98 | 3,370 |
| July 18[a] | do | 125 | 753 | 2.90 | 774 |
| August 13[b] | do | 80 | 139 | 1.96 | 443 |
| August 24[b] | Stevens and Muldrow | 82 | 114 | 1.58 | 264 |
| October 31 | Muldrow and McGlashan | 128 | 883 | 3.50 | 1,150 |
| November 27 | W. C. Muldrow | 125 | 786 | 3.01 | 780 |

[a] Large amount of dead water. [b] Measured by wading.

*Daily gage height, in feet, of Clealum River near Roslyn, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.8 | 3.1 | 2.45 | 4.0 | 6.0 | 4.4 | ..... | ..... | 1.6 | 1.7 | 3.2 | 2.7 |
| 2 | 1.75 | 3.2 | 2.4 | 4.0 | 6.1 | 4.0 | ..... | ..... | 1.6 | 1.7 | 3.1 | 2.6 |
| 3 | 1.72 | 3.15 | 2.35 | 3.9 | 6.0 | 4.1 | ..... | ..... | 1.6 | 1.8 | 2.9 | 2.5 |
| 4 | 1.72 | 3.1 | 2.3 | 3.8 | 6.0 | 4.7 | ..... | ..... | 1.6 | 1.8 | 2.8 | 2.4 |
| 5 | 1.7 | 3.0 | 2.25 | 3.9 | 5.8 | 4.8 | ..... | 2.0 | 1.6 | 1.9 | 2.7 | 2.4 |
| 6 | 1.7 | 2.9 | 2.2 | 4.4 | 5.3 | 4.5 | ..... | 2.0 | 1.6 | 1.9 | 2.7 | 2.4 |
| 7 | 1.75 | 2.8 | 2.2 | 4.7 | 5.0 | 4.1 | ..... | 2.0 | 1.6 | 1.9 | 2.8 | 2.4 |
| 8 | 1.72 | 2.7 | 2.2 | 4.9 | 4.9 | 3.9 | ..... | 2.0 | 1.6 | 1.9 | 2.9 | 2.3 |
| 9 | 1.75 | 2.6 | 2.3 | 4.8 | 5.0 | 3.8 | ..... | 2.0 | 1.6 | 1.8 | 2.9 | 2.3 |
| 10 | 1.75 | 2.55 | 2.4 | 4.5 | 5.5 | ..... | ..... | 2.0 | 1.7 | 1.8 | 3.2 | 2.3 |
| 11 | 1.75 | 2.5 | 2.5 | 4.3 | 5.7 | ..... | ..... | 2.0 | 1.7 | 1.8 | 4.0 | 2.3 |
| 12 | 1.72 | 2.4 | 2.5 | 4.0 | 5.6 | ..... | ..... | 2.0 | 1.7 | 1.9 | 4.2 | 2.3 |
| 13 | 1.72 | 2.4 | 2.58 | 3.8 | 5.1 | ..... | ..... | 2.0 | 1.7 | 1.9 | 6.3 | 2.2 |
| 14 | 1.7 | 2.32 | 2.5 | 3.7 | 4.8 | ..... | ..... | 2.0 | 1.7 | 1.9 | 11.1 | 2.2 |
| 15 | 1.7 | 2.3 | 2.5 | 3.7 | 4.7 | ..... | ..... | 2.0 | 1.7 | 2.0 | 14.0 | 2.2 |
| 16 | 1.7 | 2.25 | 2.45 | 3.9 | 4.6 | ..... | ..... | 2.0 | 1.7 | 2.2 | 11.6 | 2.2 |
| 17 | 1.7 | 2.2 | 2.4 | 4.2 | 4.2 | ..... | ..... | 2.0 | 1.7 | 2.5 | 8.6 | 2.2 |
| 18 | 1.7 | 2.4 | 2.3 | 4.3 | 4.0 | ..... | ..... | 2.0 | 1.7 | 2.7 | 6.6 | 2.2 |
| 19 | 1.7 | 2.5 | 2.28 | 4.3 | 3.9 | ..... | 2.9 | 1.9 | 1.7 | 2.8 | 5.4 | 2.3 |
| 20 | 1.7 | 2.7 | 2.1 | 4.4 | 3.8 | ..... | ..... | 1.9 | 1.6 | 2.8 | 4.8 | 2.3 |
| 21 | 1.7 | 2.8 | 2.0 | 4.9 | 3.7 | ..... | ..... | 1.1 | 1.6 | 2.7 | 4.2 | 2.3 |
| 22 | 1.8 | 2.8 | 2.0 | 5.9 | 3.7 | ..... | 2.1 | 1.1 | 1.6 | 2.6 | 3.9 | 2.4 |
| 23 | 1.8 | 2.8 | 2.0 | 6.1 | 3.7 | ..... | ..... | 1.1 | 1.6 | 2.5 | 3.6 | 2.5 |
| 24 | 2.0 | 2.7 | 1.8 | 5.7 | 3.8 | ..... | ..... | 1.1 | 1.6 | 2.5 | 3.4 | 2.5 |
| 25 | 2.3 | 2.7 | 1.8 | 5.2 | 3.9 | ..... | ..... | 1.1 | 1.7 | 2.5 | 3.3 | 2.5 |
| 26 | 2.7 | 2.7 | 1.9 | 4.9 | 4.5 | ..... | ..... | 1.4 | 1.8 | 6.7 | 3.0 | 2.5 |
| 27 | 2.9 | 2.6 | 2.0 | 4.7 | 4.9 | ..... | ..... | 1.5 | 1.8 | 6.6 | 3.0 | 2.5 |
| 28 | 3.0 | 2.52 | 2.05 | 4.7 | 4.8 | ..... | ..... | 1.5 | 1.8 | 5.4 | 2.9 | 2.4 |
| 29 | 3.0 | ..... | 2.1 | 5.0 | 4.4 | ..... | 2.0 | 1.5 | 1.9 | 4.5 | 2.8 | 2.4 |
| 30 | 3.0 | ..... | 2.5 | 5.4 | 4.2 | ..... | ..... | 1.6 | 1.9 | 3.9 | 2.7 | 2.4 |
| 31 | 3.0 | ..... | 3.4 | ..... | 4.2 | ..... | ..... | 1.6 | ..... | 3.5 | ..... | 2.4 |

*Rating table for Clealum River near Roslyn, Wash., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.10 | 140 | 2.20 | 460 | 3.30 | 940 | 4.80 | 1,970 | 6.80 | 4,160 |
| 1.20 | 165 | 2.30 | 495 | 3.40 | 995 | 5.00 | 2,150 | 7.00 | 4,400 |
| 1.30 | 190 | 2.40 | 530 | 3.50 | 1,050 | 5.20 | 2,350 | 8.00 | 5,800 |
| 1.40 | 215 | 2.50 | 570 | 3.60 | 1,110 | 5.40 | 2,550 | 9.00 | 7,340 |
| 1.50 | 240 | 2.60 | 610 | 3.70 | 1,170 | 5.60 | 2,760 | 10.00 | 9,040 |
| 1.60 | 270 | 2.70 | 650 | 3.80 | 1,230 | 5.80 | 2,980 | 11.00 | 10,900 |
| 1.70 | 300 | 2.80 | 695 | 3.90 | 1,295 | 6.00 | 3,200 | 12.00 | 12,940 |
| 1.80 | 330 | 2.90 | 740 | 4.00 | 1,360 | 6.20 | *3,440 | 13.00 | 15,200 |
| 1.90 | 360 | 3.00 | 785 | 4.20 | 1,500 | 6.40 | 3,680 | 14.00 | 17,700 |
| 2.00 | 390 | 3.10 | 835 | 4.40 | 1,640 | 6.60 | 3,920 | | |
| 2.10 | 425 | 3.20 | 885 | 4.66 | 1,800 | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1906 and is well defined between gage heights 1.4 feet and 6.0 feet.

*Monthly discharge of Clealum River near Roslyn, Wash., for 1906.*

[Drainage area, 205 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 785 | 300 | 404 | 24,800 | 1.97 | 2.27 |
| February | 885 | 460 | 644 | 35,800 | 3.14 | 3.27 |
| March | 995 | 330 | 494 | 30,400 | 2.41 | 2.78 |
| April | 3,320 | 1,170 | 1,800 | 107,000 | 8.78 | 9.80 |
| May | 3,320 | 1,170 | 2,020 | 124,000 | 9.85 | 11.36 |
| June 1–9 | 1,970 | 1,230 | 1,530 | 27,300 | 7.46 | 2.50 |
| August 5–31 | 390 | 140 | 309 | 16,500 | 1.51 | 1.52 |
| September | 360 | 270 | 293 | 17,400 | 1.43 | 1.60 |
| October | 4,040 | 300 | 831 | 51,100 | 4.06 | 4.68 |
| November | 17,700 | 650 | 2,650 | 158,000 | 12.92 | 14.40 |
| December | 650 | 460 | 522 | 32,100 | 2.54 | 2.93 |
| The period | | | | 622,000 | | |

NOTE.—Values are rated as follows: April to June, excellent; remainder of period, good.

## NACHES RIVER NEAR NILE, WASH.

This station was established June 23, 1904. It is located $1\frac{3}{8}$ miles above the highway bridge, 23 miles northwest of North Yakima, and 8 miles southeast of Nile, Wash. The station is $1\frac{3}{4}$ miles above the junction of Naches and Tieton rivers.

On November 15, 1906, the gage was destroyed by a flood. Gage heights after that date were taken from a temporary slanting gage, and have been reduced to the same datum as the old gage. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 82, where are given also references to publications that contain data for previous years.

*Discharge measurements of Naches River near Nile, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 27 | J. C. Stevens | 189 | 360 | 4.43 | 1,110 |
| May 23 | W. C. Muldrow | 190 | 409 | 4.80 | 1,530 |
| June 23 | do | 192 | 365 | 4.50 | 1,250 |
| July 14 | do | 188 | 268 | 4.00 | 626 |
| August 16 | do | 182 | 174 | 3.46 | 253 |
| November 15 [a] | do | 246 | 1,730 | 10.30 | 22,000 |
| December 9 | do | 196 | 377 | 4.00 | 1,270 |

[a] Computed from slope measurement and surface floats.

*Daily gage height, in feet, of Naches River near Nile, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.7 | 4.3 | 4.3 | 5.3 | 6.0 | 4.9 | 4.4 | 3.6 | 3.4 | 3.4 | 3.9 | 3.35 |
| 2 | 3.9 | 4.3 | 4.2 | 5.1 | 5.9 | 4.9 | 4.4 | 3.6 | 3.4 | 3.4 | 3.9 | 3.35 |
| 3 | 4.0 | 4.3 | 4.2 | 5.0 | 6.0 | 5.0 | 4.4 | 3.6 | 3.4 | 3.4 | 3.9 | 3.22 |
| 4 | 3.8 | 4.25 | 4.15 | 5.1 | 6.0 | 5.1 | 4.4 | 3.6 | 3.4 | 3.5 | 3.9 | 3.22 |
| 5 | 3.8 | 4.2 | 4.1 | 5.4 | 5.9 | 5.0 | 4.3 | 3.6 | 3.4 | 3.5 | 3.9 | 3.22 |
| 6 | 3.8 | 4.15 | 4.1 | 5.7 | 5.7 | 4.9 | 4.3 | 3.6 | 3.4 | 3.5 | 3.8 | 3.09 |
| 7 | 3.8 | 4.2 | 4.2 | 5.9 | 5.6 | 4.8 | 4.3 | 3.6 | 3.4 | 3.5 | 3.9 | 3.74 |
| 8 | 3.75 | 4.2 | 4.3 | 6.0 | 5.7 | 4.7 | 4.3 | 3.6 | 3.4 | 3.5 | 4.3 | 3.87 |
| 9 | 3.8 | 4.15 | 4.4 | 5.9 | 5.7 | 4.7 | 4.2 | 3.6 | 3.5 | 3.5 | 4.3 | 3.74 |
| 10 | 3.8 | 4.1 | 4.5 | 5.7 | 5.8 | 4.7 | 4.2 | 3.6 | 3.5 | 3.5 | 4.5 | 3.61 |
| 11 | 3.7 | 4.05 | 4.4 | 5.6 | 5.9 | 4.7 | 4.2 | 3.5 | 3.5 | 3.5 | 5.0 | 3.48 |
| 12 | 3.75 | 4.1 | 4.3 | 5.4 | 5.8 | 4.9 | 4.1 | 3.5 | 3.5 | 3.5 | 5.18 | 3.48 |
| 13 | 3.7 | 4.0 | 4.3 | 5.3 | 5.5 | 4.8 | 4.1 | 3.5 | 3.5 | 3.5 | 7.12 | 3.35 |
| 14 | 3.8 | 4.0 | 4.2 | 5.3 | 5.4 | 4.8 | 4.0 | 3.5 | 3.5 | 3.5 | 10.14 | 3.35 |
| 15 | 3.75 | 3.95 | 4.1 | 5.4 | 5.4 | 4.7 | 4.0 | 3.5 | 3.6 | 3.6 | 10.14 | 3.35 |
| 16 | 3.7 | 4.0 | 4.1 | 5.5 | 5.2 | 4.7 | 4.0 | 3.5 | 3.6 | 3.8 | 9.04 | 3.22 |
| 17 | 3.7 | 4.0 | 4.2 | 5.5 | 5.1 | 4.7 | 4.0 | 3.5 | 3.5 | 4.0 | 6.84 | 3.22 |
| 18 | 3.8 | 4.1 | 4.3 | 5.6 | 5.0 | 4.6 | 3.9 | 3.5 | 3.5 | 4.0 | 5.6 | 3.22 |
| 19 | 3.75 | 4.9 | 4.3 | 5.5 | 4.9 | 4.6 | 3.9 | 3.5 | 3.5 | 4.0 | 5.2 | 3.22 |
| 20 | 3.8 | 5.0 | 4.2 | 5.6 | 4.9 | 4.6 | 3.9 | 3.5 | 3.5 | 3.9 | 5.08 | 3.48 |
| 21 | 3.7 | 4.9 | 4.1 | 5.8 | 4.8 | 4.6 | 3.8 | 3.4 | 3.5 | 3.8 | 4.84 | 4.48 |
| 22 | 3.7 | 4.7 | 4.1 | 6.1 | 4.9 | 4.5 | 3.8 | 3.4 | 3.5 | 3.8 | 4.6 | 4.48 |
| 23 | 3.8 | 4.6 | 4.1 | 6.2 | 4.8 | 4.5 | 3.8 | 3.5 | 3.4 | 3.7 | 4.36 | 4.24 |
| 24 | 4.0 | 4.6 | 4.1 | 6.0 | 4.8 | 4.5 | 3.8 | 3.5 | 3.4 | 3.7 | 4.36 | 4.24 |
| 25 | 4.1 | 4.5 | 4.2 | 5.8 | 4.9 | 4.5 | 3.8 | 3.5 | 3.4 | 3.7 | 4.12 | 4.12 |
| 26 | 4.1 | 4.4 | 4.2 | 5.7 | 5.4 | 4.6 | 3.7 | 3.5 | 3.5 | 4.2 | 4.0 | 4.0 |
| 27 | 4.1 | 4.4 | 4.6 | 5.6 | 5.3 | 4.5 | 3.7 | 3.5 | 3.5 | 4.4 | 3.87 | 3.87 |
| 28 | 4.05 | 4.3 | 4.6 | 5.5 | 5.2 | 4.5 | 3.7 | 3.5 | 3.5 | 4.3 | 3.61 | 3.74 |
| 29 | 4.0 | ..... | 4.7 | 5.6 | 5.1 | 4.4 | 3.7 | 3.4 | 3.5 | 4.2 | 3.61 | 3.74 |
| 30 | 4.1 | ..... | 4.8 | 5.7 | 5.0 | 4.4 | 3.7 | 3.4 | 3.5 | 4.1 | 3.48 | 3.61 |
| 31 | 4.2 | ..... | 5.2 | ..... | 4.9 | ..... | 3.7 | 3.4 | ..... | 4.0 | ..... | 3.48 |

NOTE.—Gage lengths for November 12 to 17 were found by plotting several readings a day and taking the mean from the curve.

*Rating table for Naches River near Nile, Wash., from January 1, 1905, to November 15, 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.40 | 235 | 4.30 | 960 | 5.20 | 2,380 | 6.20 | 4,740 | 8.00 | 10,700 |
| 3.50 | 280 | 4.40 | 1,090 | 5.30 | 2,580 | 6.40 | 5,300 | 8.20 | 11,520 |
| 3.60 | 330 | 4.50 | 1,230 | 5.40 | 2,780 | 6.60 | 5,880 | 8.40 | 12,360 |
| 3.70 | 390 | 4.60 | 1,380 | 5.50 | 3,000 | 6.80 | 6,480 | 8.60 | 13,240 |
| 3.80 | 460 | 4.70 | 1,530 | 5.60 | 3,220 | 7.00 | 7,100 | 8.80 | 14,160 |
| 3.90 | 540 | 4.80 | 1,690 | 5.70 | 3,460 | 7.20 | 7,740 | 9.00 | 15,100 |
| 4.00 | 630 | 4.90 | 1,850 | 5.80 | 3,700 | 7.40 | 8,420 | 10.00 | 20,320 |
| 4.10 | 730 | 5.00 | 2,020 | 5.90 | 3,960 | 7.60 | 9,140 | | |
| 4.20 | 840 | 5.10 | 2,200 | 6.00 | 4,220 | 7.80 | 9,900 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is well defined below gage height 5 feet.

*Monthly discharge of Naches River near Nile, Wash., for 1906.*

[Drainage area, 636 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 840 | 390 | 513 | 31,500 | 0.807 | 0.93 |
| February | 2,020 | 585 | 1,010 | 56,100 | 1.59 | 1.66 |
| March | 2,380 | 730 | 996 | 61,200 | 1.57 | 1.81 |
| April | 4,740 | 2,020 | 3,250 | 193,000 | 5.11 | 5.70 |
| May | 4,220 | 1,690 | 2,810 | 173,000 | 4.42 | 5.10 |
| June | 2,200 | 1,090 | 1,530 | 91,000 | 2.41 | 2.69 |
| July | 1,090 | 390 | 676 | 41,600 | 1.06 | 1.22 |
| August | 330 | 235 | 289 | 17,800 | .454 | .52 |
| September | 330 | 235 | 267 | 15,900 | .420 | .47 |
| October | 1,090 | 235 | 458 | 28,200 | .720 | .83 |
| November 1–15 | 21,100 | 460 | 4,060 | 121,000 | 6.38 | 3.56 |
| The period | | | | 800,000 | | |

NOTE.—Values are rated as follows: January to May and November, good; June to October, excellent.

## NACHES RIVER NEAR NORTH YAKIMA, WASH.

The original station on Naches River was established August 14, 1893, at a point a few hundred yards above the mouth of the river, near the bridge of the Northern Pacific Railway.

On April 24, 1906, a standard chain gage was installed at the highway bridge above the cable; length of chain, 27.10 feet. After April 28, 1906, this gage was read by Mrs. A. M. Cole. The flood of November 16, 1906, swept out this gage with the bridge and changed the channel. A temporary vertical gage, installed November 22, at the same datum, was read during the remainder of the year. The bench mark is a brass plug in the top of the concrete-filled steel pier, 10 feet north of the gage; elevation, 21.74 feet above the datum of the gage and 1,093.87 feet above sea level.

The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 86, where are given also references to publications that contain data for previous years.

*Discharge measurements of Naches River near North Yakima, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 26 | Stevens and Muldrow | 130 | 387 | [a] 5.35 | 970 |
| April 3 | W. C. Muldrow | 143 | 576 | [a] 6.15 | 2,140 |
| April 25 | do | 158 | 644 | 6.45 | 3,790 |
| May 28 | do | 142 | 452 | 5.67 | 2,440 |
| June 21 | do | 132 | 307 | 4.48 | 1,280 |
| July 10 | do | 127 | 248 | 4.00 | 961 |
| August 20 | J. C. Stevens | 57 | 33 | 2.10 | 40 |
| October 26 | Muldrow and McGlashan | 131 | 322 | 4.40 | 1,230 |
| November 14 [b] | W. C. Muldrow | 270 | 1,820 | 11.50 | 24,300 |
| November 22 | do | 240 | 923 | 8.20 | 3,590 |

[a] Gage height from inclined gage; other gage heights are from chain gage.
[b] Measured by floats.

*Daily gage height, in feet, of Naches River near North Yakima, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.3 | 5.2 | 5.3 | 6.35 | 6.9 | 5.2 | 4.1 | 2.6 | 2.0 | 2.1 | 3.6 | 7.5 |
| 2 | 4.3 | 5.2 | 5.2 | 6.3 | 6.9 | 5.1 | 4.0 | 2.5 | 2.0 | 2.4 | 3.5 | 7.5 |
| 3 | 4.4 | 5.2 | 5.2 | 6.1 | 7.0 | 5.6 | 4.1 | 2.3 | 2.0 | 2.3 | 3.5 | 7.4 |
| 4 | 4.4 | 5.2 | 5.1 | 6.3 | 7.1 | 5.7 | 4.2 | 2.3 | 2.1 | 2.4 | 3.6 | 7.4 |
| 5 | 4.4 | 5.2 | 5.0 | 6.6 | 6.7 | 5.4 | 4.2 | 2.5 | 1.9 | 2.5 | 3.5 | 7.4 |
| 6 | 4.4 | 5.2 | 5.0 | 7.0 | 6.0 | 5.1 | 4.2 | 2.3 | 2.0 | 2.5 | 3.4 | 7.5 |
| 7 | 4.3 | 5.1 | 5.0 | 7.3 | 6.4 | 4.9 | 4.4 | 2.4 | 2.4 | 2.4 | 3.6 | 7.5 |
| 8 | 4.3 | 5.1 | 5.2 | ..... | 6.2 | 4.8 | 4.3 | 2.2 | 2.5 | 2.5 | 4.8 | 7.7 |
| 9 | 4.3 | 5.0 | 5.5 | 7.3 | 6.4 | 4.8 | 4.1 | 2.3 | 2.5 | 2.5 | 4.4 | 7.7 |
| 10 | 4.3 | 5.0 | 5.5 | 7.1 | 6.8 | 4.7 | 3.9 | 2.2 | 2.3 | 2.5 | 4.8 | 7.6 |
| 11 | 4.3 | 4.95 | 5.4 | 6.9 | 6.8 | 4.7 | 4.0 | 2.2 | 2.3 | 2.4 | 5.8 | 7.5 |
| 12 | 4.2 | 4.9 | 5.3 | 6.6 | 6.6 | 5.0 | 3.9 | 2.3 | 2.2 | 2.5 | 5.6 | 7.4 |
| 13 | 4.2 | 4.9 | 5.3 | 6.5 | 6.2 | 5.0 | 3.8 | 2.3 | 2.0 | 2.5 | 9.1 | 7.3 |
| 14 | 4.2 | 4.8 | 5.3 | 6.6 | 5.9 | 4.8 | 3.7 | 2.4 | 2.3 | 2.5 | 11.15 | 7.3 |
| 15 | 4.2 | 4.8 | 5.2 | ..... | 6.0 | 4.7 | 3.7 | 2.3 | 2.7 | 2.7 | 10.7 | 7.2 |
| 16 | 4.2 | 4.8 | 5.2 | 6.7 | 5.8 | 4.8 | 3.8 | 2.4 | 2.5 | 2.7 | 10.7 | 7.3 |
| 17 | 4.2 | 4.7 | 5.2 | 6.7 | 5.6 | 4.8 | 3.5 | 2.2 | 2.4 | 3.6 | 9.7 | 7.3 |
| 18 | 4.2 | 5.5 | 5.1 | 6.7 | 5.2 | 4.7 | 3.4 | 2.1 | 2.3 | 3.6 | (a) | 7.2 |
| 19 | 4.2 | 6.3 | 5.1 | 6.8 | 5.0 | 4.6 | 3.4 | 2.0 | 2.2 | 3.4 | ..... | 7.2 |
| 20 | 4.2 | 6.2 | 5.1 | 6.8 | 5.0 | 4.5 | 3.2 | 2.1 | 2.3 | 3.3 | ..... | 7.3 |
| 21 | 4.2 | 6.1 | 5.1 | 7.1 | 4.7 | 4.5 | 3.1 | 2.1 | 2.3 | 3.3 | ..... | 8.5 |
| 22 | 4.2 | 5.9 | 5.0 | ..... | 4.8 | 4.5 | 3.0 | 2.1 | 2.3 | 3.2 | ..... | 8.6 |
| 23 | 4.4 | 5.8 | 5.0 | 7.6 | 4.9 | 4.4 | 3.1 | 2.1 | 2.3 | 3.0 | ..... | 8.3 |
| 24 | 4.5 | 5.6 | 5.0 | 7.3 | 5.0 | 4.3 | 3.0 | 1.9 | 2.4 | 3.0 | ..... | 8.3 |
| 25 | 4.7 | 5.55 | 5.0 | 7.1 | 5.1 | 4.4 | 2.8 | 2.1 | 2.4 | 3.0 | 7.9 | 8.1 |
| 26 | 4.9 | 5.5 | 5.0 | 7.0 | 6.2 | 4.6 | 2.9 | 2.0 | 2.3 | 4.0 | 7.8 | 8.0 |
| 27 | 4.9 | 5.4 | 5.2 | 6.8 | 6.0 | 4.4 | 2.8 | 2.0 | 2.2 | 4.8 | 7.7 | 7.9 |
| 28 | 4.9 | 5.3 | 5.8 | 5.9 | 5.9 | 4.2 | 2.7 | 2.0 | 2.4 | 4.4 | 7.6 | 7.9 |
| 29 | 4.9 | ..... | 5.9 | 6.1 | 5.7 | 4.1 | 3.1 | 2.5 | 2.2 | 4.0 | 7.6 | 7.9 |
| 30 | 4.9 | ..... | 6.0 | 6.4 | 5.5 | 4.0 | 2.8 | 2.0 | 2.2 | 3.8 | 7.5 | 7.8 |
| 31 | 5.1 | ..... | 6.4 | ..... | 5.4 | ..... | 2.7 | 2.2 | ..... | 3.6 | ..... | 7.7 |

[a] Gage and bridge destroyed by flood.

*Rating tables for Naches River near North Yakima, Wash.*

JANUARY 1 TO APRIL 29, 1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 4.20 | 285 | 4.90 | 650 | 5.60 | 1,280 | 6.30 | 2,190 | 7.00 | 3,360 |
| 4.30 | 325 | 5.00 | 720 | 5.70 | 1,390 | 6.40 | 2,340 | 7.10 | 3,540 |
| 4.40 | 370 | 5.10 | 800 | 5.80 | 1,510 | 6.50 | 2,500 | 7.20 | 3,730 |
| 4.50 | 420 | 5.20 | 880 | 5.90 | 1,630 | 6.60 | 2,660 | 7.30 | 3,920 |
| 4.60 | 470 | 5.30 | 970 | 6.00 | 1,760 | 6.70 | 2,830 | 7.40 | 4,110 |
| 4.70 | 525 | 5.40 | 1,070 | 6.10 | 1,900 | 6.80 | 3,000 | 7.50 | 4,300 |
| 4.80 | 585 | 5.50 | 1,170 | 6.20 | 2,040 | 6.90 | 3,180 | 7.60 | 4,500 |

APRIL 28 TO NOVEMBER 14, 1906.[b]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.10 | 5 | 2.10 | 45 | 3.10 | 365 | 4.20 | 1,055 | 6.20 | 3,350 |
| 1.20 | 7 | 2.20 | 60 | 3.20 | 415 | 4.40 | 1,210 | 6.40 | 3,670 |
| 1.30 | 9 | 2.30 | 75 | 3.30 | 470 | 4.60 | 1,380 | 6.60 | 4,000 |
| 1.40 | 11 | 2.40 | 95 | 3.40 | 525 | 4.80 | 1,570 | 6.80 | 4,340 |
| 1.50 | 14 | 2.50 | 120 | 3.50 | 585 | 5.00 | 1,780 | 7.00 | 4,700 |
| 1.60 | 17 | 2.60 | 150 | 3.60 | 645 | 5.20 | 2,000 | 8.00 | 6,880 |
| 1.70 | 21 | 2.70 | 185 | 3.70 | 710 | 5.40 | 2,240 | 9.00 | 10,100 |
| 1.80 | 25 | 2.80 | 225 | 3.80 | 775 | 5.60 | 2,500 | 10.00 | 14,800 |
| 1.90 | 30 | 2.90 | 270 | 3.90 | 840 | 5.80 | 2,770 | 11.00 | 20,900 |
| 2.00 | 35 | 3.00 | 315 | 4.00 | 910 | 6.00 | 3,050 | | |

[a] This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is fairly well defined below gage height 6.2 feet.

[b] This table is applicable only for open-channel conditions. It is based on 7 discharge measurements made during 1906 and is well defined between gage heights 2.0 feet and 6.5 feet.

*Monthly discharge of Naches River near North Yakima, Wash., for 1906.*

[Drainage area, 1,120 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 800 | 285 | 395 | 24,300 | 0.353 | 0.41 |
| February | 2,190 | 525 | 1,030 | 57,200 | .920 | .96 |
| March | 2,340 | 720 | 982 | 60,400 | .877 | 1.01 |
| April | 4,500 | 1,900 | 3,120 | 186,000 | 2.79 | 3.11 |
| May | 4,890 | 1,470 | 3,040 | 187,000 | 2.71 | 3.12 |
| June | 2,630 | 910 | 1,550 | 92,200 | 1.38 | 1.54 |
| July | 1,210 | 185 | 646 | 39,700 | .577 | .67 |
| August | 150 | 30 | 67.6 | 4,160 | .060 | .07 |
| September | 185 | 30 | 74.8 | 4,450 | .067 | .07 |
| October | 1,570 | 45 | 386 | 23,700 | .345 | .40 |
| November 1–14 | 21,900 | 525 | 3,300 | 91,600 | 2.95 | 1.54 |
| The period | | | | 771,000 | | |

NOTE.—Values are rated as follows: January to April, good; July to November, fair.

## BUMPING RIVER NEAR NILE, WASH.

This station was established June 13, 1906, for the Tieton project of the United States Reclamation Service. It is located at the outlet of Bumping Lake.

Discharge measurements are made by wading.

The gage, which was read during a part of 1906 by employees of the Reclamation Service, is a vertical staff fastened to the stump of a tree, at the point where the trail crosses the river, 2,000 feet below the lake.

*Discharge measurements of Bumping River near Nile, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| June 13 | W. C. Muldrow | 110 | 193 | 1.40 | 352 |
| July 9 | C. E. Hewitt | 120 | 171 | 1.02 | 266 |
| July 14 | do | 116 | 141 | .76 | 198 |
| July 18 | do | 115 | 126 | .63 | 161 |
| July 23 | do | 115 | 114 | .52 | 136 |
| July 28 | do | 115 | 105 | .44 | 120 |
| November 14[a] | W. C. Muldrow | 140 | 900 | 7.00 | 6,000 |
| December 7 | do | 110 | 201 | 1.50 | 407 |

[a] Computed from measurements of slope.

*Daily gage height, in feet, of Bumping River near Nile, Wash., for 1906.*

| Day. | June. | July. | Day. | June. | July. | Day. | June. | July. |
|---|---|---|---|---|---|---|---|---|
| 1 | | 1.05 | 12 | | .85 | 23 | 1.15 | 0.5 |
| 2 | | 1.05 | 13 | 1.5 | .8 | 24 | 1.1 | .5 |
| 3 | | 1.05 | 14 | 1.4 | .75 | 25 | 1.1 | .5 |
| 4 | | 1.2 | 15 | 1.35 | .75 | 26 | 1.1 | .5 |
| 5 | | 1.15 | 16 | 1.4 | .7 | 27 | 1.1 | .45 |
| 6 | | 1.2 | 17 | 1.35 | .65 | 28 | 1.05 | .45 |
| 7 | | 1.1 | 18 | 1.3 | .65 | 29 | 1.05 | .45 |
| 8 | | 1.05 | 19 | 1.25 | .6 | 30 | 1.05 | .4 |
| 9 | | 1.0 | 20 | 1.2 | .6 | 31 | | .4 |
| 10 | | .9 | 21 | 1.2 | .6 | | | |
| 11 | | .9 | 22 | 1.15 | .55 | | | |

*Rating table for Bumping River near Nile, Wash., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.40 | 122 | 0.70 | 176 | 1.00 | 251 | 1.30 | 347 |
| 0.50 | 137 | 0.80 | 199 | 1.10 | 281 | 1.40 | 382 |
| 0.60 | 155 | 0.90 | 224 | 1.20 | 314 | 1.50 | 417 |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 7 discharge measurements made during 1906 and is well defined.

*Monthly discharge of Bumping River near Nile, Wash., for 1906.*

[Drainage area 68 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| June 13–30 | 417 | 266 | 318 | 11,400 | 4.68 | 3.13 |
| July | 314 | 122 | 195 | 12,000 | 2.87 | 3.31 |
| The period | | | | 23,400 | | |

NOTE.—Values are rated as excellent.

## TIETON RIVER AT HEADWORKS NEAR NACHES, WASH.

This station was established March 29, 1906. It is located 1 mile below the diversion point of the proposed canal of the Tieton project of the Reclamation Service, about 15 miles from the mouth of the river.

The river flows in a narrow canyon cut in basalt. The channel is straight. The right bank is low and brush-covered, and overflows at high water; the left is fairly high and clean. The bed of the stream is of bowlders and gravel, and permanent. There is one channel at all stages. The current is swift and somewhat broken.

Measurements are made from a cable and car.

A vertical 1 by 4 inch gage is drift-bolted to a bowlder at the cable station. The bench mark is a spike in the root of a large pine, 50 feet southeast of the stump to which the cable is attached; elevation, 16.11 feet above the datum of the gage.

*Discharge measurements of Tieton River at headworks near Naches, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 12 | W. C. Muldrow | 75 | 158 | | 416 |
| March 29 | J. C. Stevens | 94 | 182 | 3.47 | 525 |
| April 17 | W. C. Muldrow | 95 | 220 | 3.90 | 763 |
| June 2 | do | 95 | 195 | 3.66 | 644 |
| September 8 | do | 76 | 142 | 3.12 | 352 |

*Daily gage height, in feet, of Tieton River at Headworks near Naches, Wash., for 1906.*

| Day. | Apr. | May. | June. | July. | Sept. | Day. | Apr. | May. | June. | July. | Sept. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | 4.25 | | | | 21 | 4.4 | 3.6 | | 3.25 | |
| 7 | | 4.2 | | | | 22 | 4.6 | | | | |
| 12 | | 4.3 | | | | 23 | 4.45 | | | | |
| 13 | | 4.0 | | | | 24 | 4.3 | | | 3.3 | |
| 14 | | 4.0 | | | | 25 | 4.15 | | | | |
| 15 | | 4.0 | | | | 26 | 4.0 | | | | |
| 16 | | 3.9 | | | | 27 | 4.0 | | | | |
| 17 | 3.9 | 3.8 | | | 2.86 | 28 | 3.95 | | 2.4 | | |
| 18 | 3.9 | 3.65 | | | | 29 | 4.2 | | | | |
| 19 | 3.9 | 3.6 | | | | 30 | 4.3 | | | | |
| 20 | 4.1 | 3.7 | | | | | | | | | |

## TIETON RIVER NEAR NACHES,[a] WASH.

This station was established April 24, 1902, at a point immediately below the mouth of Oak Creek, in sec. 3, T. 14 N., R. 16 E. of the Willamette meridian, about 3 miles above the mouth of Tieton River and about 22 miles from North Yakima by road. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 89, where are given also references to publications that contain data for previous years. The station was moved upstream March 7, 1906, above the mouth of Oak Creek.

The channel is straight. The banks are high and do not overflow. The bed of the stream is of gravel and solid basalt and changes only during extreme floods. There is one channel at all stages. The current is very swift.

Measurements are made by means of a cable, car, and tagged wire.

The gage, which was read twice a day by Oscar M. Cobb during 1906, is a vertical staff, in two sections: The lower section is bolted to the downstream side of a large bowlder; the upper section is spiked to a tree 20 feet upstream. The bench mark is the highest point of the bowlder to which the gage is attached; elevation, 1,694.65 feet above sea level and 9.25 feet above the datum of the gage.

*Discharge measurements of Tieton River near Naches, Wash., in 1906–7.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 7 | W. C. Muldrow | 69 | 147 | [b] 6.10 | 333 |
| March 27 | J. C. Stevens | 73 | 160 | 6.40 | 474 |
| March 30 | do | 74 | 180 | 6.71 | 645 |
| May 22 | W. C. Muldrow | 73 | 173 | 6.63 | 603 |
| June 22 | do | 72 | 166 | 6.41 | 532 |
| July 14 | do | 74 | 187 | 6.70 | 657 |
| August 15 | do | 71 | 151 | 6.20 | 414 |
| November 16[c] | do | 125 | 728 | 9.70 | 5,540 |
| 1907. | | | | | |
| February 2 | do | 65 | 212 | 4.80 | 520 |

[a] Station formerly referred to as near North Yakima, Wash.
[b] Old gage read 7.20 feet.
[c] Measured by floats.

*Daily gage height, in feet, of Tieton River near Naches, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.50 | 7.30 | 7.18 | 6.95 | 7.65 | 6.75 | 6.60 | 6.15 | 5.98 | 5.68 | 5.80 | 5.15 |
| 2 | 6.47 | 7.30 | 7.18 | 6.80 | 7.55 | 6.78 | 6.68 | 6.12 | 5.92 | 5.82 | 5.70 | 5.10 |
| 3 | 6.60 | 7.22 | 7.20 | 6.78 | 7.65 | 7.00 | 6.85 | 6.08 | 5.98 | 5.90 | 5.72 | 5.05 |
| 4 | 6.65 | 7.15 | 7.15 | 6.92 | 7.70 | 7.18 | 6.85 | 6.12 | 5.90 | 5.75 | 5.88 | 5.00 |
| 5 | 6.65 | 7.12 | 7.10 | 7.20 | 7.52 | 6.90 | 6.95 | 6.12 | 5.90 | 5.65 | 5.90 | 5.00 |
| 6 | 6.62 | 7.00 | 7.10 | 7.42 | 7.40 | 6.75 | 6.95 | 6.20 | 6.05 | 5.68 | 5.80 | 5.75 |
| 7 | 6.60 | 6.98 | 7.20 | 7.70 | 7.35 | 6.65 | 6.90 | 6.18 | 6.18 | 5.70 | 6.00 | 5.52 |
| 8 | 6.60 | 7.05 | 7.30 | 7.58 | 7.38 | 6.58 | 6.80 | 6.22 | 6.05 | 5.78 | 6.92 | 5.52 |
| 9 | 6.60 | 6.98 | 6.25 | 7.45 | 7.50 | 6.55 | 6.70 | 6.20 | 5.88 | 5.70 | 6.70 | 5.40 |
| 10 | 6.55 | 6.95 | 6.25 | 7.28 | 7.62 | 6.48 | 6.72 | 6.22 | 5.68 | 5.75 | 7.55 | 5.30 |
| 11 | 6.55 | 6.88 | 6.05 | 7.12 | 7.62 | 6.62 | 6.7 | 6.25 | 5.58 | 5.75 | 7.25 | 5.28 |
| 12 | 6.55 | 6.92 | 6.00 | 6.98 | 7.42 | 6.95 | 6.68 | 6.25 | 5.60 | 5.75 | 8.60 | 5.15 |
| 13 | 6.58 | 6.90 | 6.00 | 6.92 | 7.20 | 6.75 | 6.62 | 6.25 | 5.55 | 5.65 | 11.80 | 5.02 |
| 14 | 6.50 | 6.90 | 6.02 | 6.92 | 7.15 | 6.58 | 6.65 | 6.10 | 5.68 | 5.81 | 13.75 | 4.92 |
| 15 | 6.50 | 6.88 | 6.00 | 7.02 | 7.25 | 6.58 | 6.58 | 6.22 | 5.68 | 5.78 | 13.70 | 5.00 |
| 16 | 6.58 | 6.85 | 6.00 | 7.12 | 7.00 | 6.68 | 6.55 | 6.10 | 5.60 | 6.08 | 10.00 | 4.95 |
| 17 | 6.52 | 6.88 | 6.00 | 7.12 | 6.82 | 6.65 | 6.48 | 6.00 | 5.72 | 6.15 | 7.75 | 4.95 |
| 18 | 6.48 | 7.50 | 5.98 | 7.10 | 6.72 | 6.58 | 6.38 | 6.00 | 5.85 | 5.92 | 7.25 | 4.92 |
| 19 | 6.55 | 8.60 | 5.95 | 7.12 | 6.68 | 6.52 | 6.35 | 5.92 | 5.90 | 5.78 | 6.90 | 5.00 |
| 20 | 6.50 | 8.18 | 5.95 | 7.30 | 6.62 | 6.48 | 6.28 | 5.95 | 5.90 | 5.72 | 6.50 | 6.15 |
| 21 | 6.50 | 7.90 | 5.92 | 7.62 | 6.62 | 6.52 | 6.30 | 5.92 | 5.90 | 5.68 | 6.25 | 7.25 |
| 22 | 6.50 | 7.75 | 5.92 | 7.70 | 6.60 | 6.45 | 6.38 | 5.90 | 5.82 | 5.62 | 6.05 | 6.85 |
| 23 | 6.60 | 7.65 | 5.95 | 7.65 | 6.65 | 6.40 | 6.30 | 5.75 | 5.85 | 5.62 | 5.82 | 6.55 |
| 24 | 6.80 | 7.58 | 6.02 | 7.45 | 6.65 | 6.55 | 6.22 | 5.90 | 5.90 | 5.62 | 5.72 | 6.60 |
| 25 | 6.82 | 7.45 | 6.08 | 7.30 | 7.18 | 6.58 | 6.25 | 6.05 | 5.78 | 6.00 | 5.62 | 6.25 |
| 26 | 6.90 | 7.42 | 6.22 | 7.22 | 7.50 | 6.75 | 6.28 | 6.05 | 5.65 | 7.20 | 5.48 | 6.10 |
| 27 | 7.05 | 7.38 | 6.40 | 7.20 | 7.15 | 6.55 | 6.20 | 6.05 | 5.62 | 6.72 | 5.40 | 5.95 |
| 28 | 6.90 | 7.30 | 6.60 | 7.22 | 7.00 | 6.45 | 6.22 | 6.05 | 5.82 | 6.32 | 5.32 | 5.85 |
| 29 | 6.92 | ..... | 6.60 | 7.30 | 6.88 | 6.32 | 6.25 | 6.08 | 5.72 | 6.10 | 5.30 | 5.78 |
| 30 | 7.05 | ..... | 6.75 | 7.35 | 6.82 | 6.40 | 6.25 | 6.12 | 5.68 | 5.98 | 5.20 | 5.70 |
| 31 | 7.22 | ..... | 7.15 | ..... | 6.72 | ..... | 6.22 | 6.05 | ..... | 5.88 | ..... | 5.55 |

NOTE.—Gage heights prior to March 9 are for a different gage and datum from those after that date. Gage heights from November 12 to 17 were found by plotting several readings a day and taking the mean from the curve.

*Rating tables for Tieton River near Naches, Wash.*

JANUARY 1, 1905, TO MARCH 8, 1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 6.30 | 195 | 6.80 | 249 | 7.30 | 365 | 7.80 | 575 | 8.30 | 920 |
| 6.40 | 202 | 6.90 | 267 | 7.40 | 400 | 7.90 | 630 | 8.40 | 1,020 |
| 6.50 | 210 | 7.00 | 287 | 7.50 | 440 | 8.00 | 690 | 8.50 | 1,130 |
| 6.60 | 220 | 7.10 | 310 | 7.60 | 480 | 8.10 | 755 | 8.60 | 1,250 |
| 6.70 | 233 | 7.20 | 335 | 7.70 | 525 | 8.20 | 830 | | |

MARCH 9 TO NOVEMBER 14, 1906.[b]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5.50 | 155 | 6.60 | 593 | 7.70 | 1,370 | 8.80 | 2,530 | 10.80 | 5,720 |
| 5.60 | 182 | 6.70 | 649 | 7.80 | 1,460 | 8.90 | 2,650 | 11.00 | 6,120 |
| 5.70 | 212 | 6.80 | 708 | 7.90 | 1,555 | 9.00 | 2,780 | 11.20 | 6,560 |
| 5.80 | 244 | 6.90 | 770 | 8.00 | 1,650 | 9.20 | 3,040 | 11.40 | 7,000 |
| 5.90 | 278 | 7.00 | 835 | 8.10 | 1,750 | 9.40 | 3,320 | 11.60 | 7,440 |
| 6.00 | 315 | 7.10 | 905 | 8.20 | 1,850 | 9.60 | 3,610 | 11.80 | 7,920 |
| 6.10 | 355 | 7.20 | 975 | 8.30 | 1,960 | 9.80 | 3,920 | 12.00 | 8,400 |
| 6.20 | 398 | 7.30 | 1,050 | 8.40 | 2,070 | 10.00 | 4,240 | 13.00 | 11,000 |
| 6.30 | 443 | 7.40 | 1,125 | 8.50 | 2,180 | 10.20 | 4,580 | 14.00 | 14,000 |
| 6.40 | 490 | 7.50 | 1,205 | 8.60 | 2,290 | 10.40 | 4,940 | 15.00 | 17.700 |
| 6.50 | 540 | 7.60 | 1,285 | 8.70 | 2,410 | 10.60 | 5,320 | | |

[a] This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904–6, and is well defined between gage heights 6.7 feet and 7.3 feet.

[b] This table is applicable only for open-channel conditions. It is based on 7 discharge measurements made during 1906, and is well defined between gage heights 6 feet and 7 feet. The table has been extended beyond these limits by means of curves of area and mean velocity.

*Rating tables for Tieton River near Naches, Wash.*—Continued.

NOVEMBER 15 TO DECEMBER 31, 1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 4.90 | 530 | 5.80 | 1,030 | 6.70 | 1,740 | 7.60 | 2,665 | 9.00 | 4,480 |
| 5.00 | 560 | 5.90 | 1,100 | 6.80 | 1,830 | 7.70 | 2,780 | 10.00 | 6,000 |
| 5.10 | 600 | 6.00 | 1,170 | 6.90 | 1,925 | 7.80 | 2,900 | 11.00 | 7,750 |
| 5.20 | 645 | 6.10 | 1,245 | 7.00 | 2,020 | 7.90 | 3,020 | 12.00 | 9,800 |
| 5.30 | 700 | 6.20 | 1,320 | 7.10 | 2,120 | 8.00 | 3,140 | 13.00 | 12,200 |
| 5.40 | 760 | 6.30 | 1,400 | 7.20 | 2,225 | 8.20 | 3,390 | 14.00 | 14,950 |
| 5.50 | 825 | 6.40 | 1,480 | 7.30 | 2,330 | 8.40 | 3,650 | | |
| 5.60 | 890 | 6.50 | 1,565 | 7.40 | 2,440 | 8.60 | 3,920 | | |
| 5.70 | 960 | 6.60 | 1,650 | 7.50 | 2,550 | 8.80 | 4,195 | | |

[a] This table is applicable only for open-channel conditions. It is based on 2 discharge measurements made during 1906–7 and the form of previous curves, and is not well defined.

*Monthly discharge of Tieton River near Naches, Wash., for 1906.*

[Drainage area, 289 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 341 | 208 | 232 | 14,300 | 0.803 | 0.93 |
| February | 1,250 | 258 | 401 | 22,300 | 1.39 | 1.45 |
| March | 940 | 285 | 382 | 23,500 | 1.32 | 1.52 |
| April | 1,370 | 696 | 1,000 | 59,500 | 3.46 | 3.86 |
| May | 1,370 | 593 | 956 | 58,800 | 3.31 | 3.82 |
| June | 961 | 452 | 616 | 36,700 | 2.13 | 2.38 |
| July | 802 | 398 | 560 | 34,400 | 1.94 | 2.24 |
| August | 420 | 228 | 350 | 21,500 | 1.21 | 1.40 |
| September | 389 | 168 | 250 | 14,900 | .865 | .57 |
| October | 975 | 188 | 289 | 17,800 | 1.00 | 1.91 |
| November | 14,100 | 212 | 2,220 | 132,000 | 7.68 | 8.57 |
| December | 2,280 | 536 | 921 | 56,600 | 3.19 | 3.68 |
| The year | 14,100 | 168 | 681 | 492,000 | 2.36 | 31.97 |

NOTE.—Values are rated as follows: January to May, good; June to October, excellent; November and December, fair.

## LOW-WATER MEASUREMENTS OF TRIBUTARIES OF LAKE KACHESS.

Small streams discharging into Lake Kachess were measured during the low-water season of 1906 with the following results:

*Discharge measurements at low water of tributaries of Kachess Lake, Washington, in 1906.*

| Date. | Stream. | Discharge. |
|---|---|---|
| | East shore: | *Sec.-ft.* |
| August 22 | First creek from outlet | 1.0 |
| August 22 | Second creek from outlet | 2.2 |
| August 22 | Third creek from outlet | 1.6 |
| August 22 | Fourth creek from outlet | 2.1 |
| August 22 | Fifth creek from outlet | 1.0 |
| August 22 | Sixth creek from outlet | 0.3 |
| August 22 | Honolulu Creek | 0.5 |
| | West shore: | |
| August 22 | Main Creek | 5.8 |
| August 22 | Tributary to Main Creek | 0.1 |
| August 23 | Ninth creek from outlet | 0.4 |
| August 23 | Eighth creek from outlet | 0.1 |
| August 23 | Seventh creek from outlet | 0.2 |
| August 23 | Box Canyon | 14 |
| August 23 | Gale Creek | 0.8 |
| August 23 | Fourth creek from outlet | 0.5 |
| August 23 | Third creek from outlet | 0.2 |
| August 23 | Second creek from outlet | 0.7 |
| August 23 | First creek from outlet | 1.5 |

## LOW-WATER MEASUREMENTS OF TRIBUTARIES OF LAKE KEECHELUS.

A number of tributaries of Lake Keechelus were measured during the low-water season of 1906, and the results are shown in the following table:

*Discharge measurements at low water of tributaries of Keechelus Lake in 1906.*

| Date. | Stream. | Width. | Area of section. | Discharge. |
|---|---|---|---|---|
| | East shore: | *Feet.* | *Sq. ft.* | *Sec.-ft.* |
| August 21 [a] | First creek from outlet | 3.5 | 0.8 | 0.8 |
| August 21 [b] | Second creek from outlet | | | .2 |
| August 21 | Trout Creek | | | 1.8 |
| August 21 | Fourth creek from outlet | 5 | 1.25 | 1.8 |
| August 21 | Fifth creek from outlet | | | 0.5 |
| August 21 | Sixth creek from outlet | | | 6 |
| August 21 [b] | Boulder Creek | | | 2.5 |
| August 21 [a] | Gold Creek | 15 | 7.5 | 25 |
| | West shore: | | | |
| August 21 | Coal Creek | 5 | 2.8 | 2.5 |
| August 21 | Roaring Creek | 15 | 12 | 36 |
| August 21 [c] | Meadow Creek | 10 | 4 | 3.6 |

[a] Measured by floats one-half mile above mouth.
[b] Estimated.
[c] Measured by floats 1 mile above mouth.

## MISCELLANEOUS MEASUREMENTS.

The following miscellaneous discharge measurements were made in Yakima River drainage basin during 1906:

*Atanum Creek.*—Measurements were made 2½ miles below Tampico:

April 20 (high water), width, 29 feet; area, 69 square feet; discharge, 207 second-feet.

August 28 (low water), width, 20 feet; area, 11 square feet; discharge, 7.6 second-feet.

A measurement was made at low water August 29 at The Narrows. The water surface was 3.82 feet below a spike in a tree on the right bank near the foot log:

Width, 20 feet; area, 20 square feet; discharge, 20 second-feet.

*North Fork of Atanum Creek.*—Measurements made at Tampico. The reference point is a nail in a stump on the right bank 2 feet above the second bridge; gage heights are below the reference point:

April 19, width, 30 feet; area, 52 square feet; gage height, —2.00 feet; discharge, 190 second-feet.

August 28, width, 16 feet; area, 11 square feet; gage height, —3.62 feet; discharge, 20 second-feet.

August 29, discharge, 17 second-feet; creek in four channels.

*South Fork of Atanum Creek.*—Measurements were made 1 mile above Tampico:

April 20 (high water); width, 16 feet; area, 18 square feet; discharge, 54 second-feet.

August 29 (low water); width, 11 feet; area, 10 square feet; discharge, 8.6 second-feet.

*Cabin Creek near Easton, Wash.*—The discharge of this stream at the wagon bridge on Snoqualmie Road was estimated August 21, at low water, as 7 second-feet.

*Clealum River above Lake Clealum.*—A measurement was made August 24, 1906, at low water, 2 miles above the head of the lake:

Width, 53 feet; area, 75 square feet; discharge, 189 second-feet.

*Cowiche Creek near Cowiche, Wash.*—A measurement was made June 3, 1906, just below the head of Cowiche canal:

Width, 18 feet; area, 31 square feet; discharge, 37 second-feet.

*South Fork of Cowiche Creek near Cowiche, Wash.*—Measurements were made just above the head of the canal:

April 18; width, 19 feet; area, 33 square feet; discharge, 64 second-feet.
September 1; width, 2 feet; area, 0.75 square foot; discharge, 0.71 second-foot.

*North Fork of Cowiche Creek.*—A measurement was made by floats April 18, 1906, at the corner of sections 20, 21, 28, and 29, T. 14 N., R. 17 E.:

Width, 6 feet; area, 1.8 square feet; discharge, 2.7 second-feet.

*Desolation Creek near Roslyn, Wash.*—A measurement was made at low water August 24, 1906, one-half mile above mouth:

Width, 4 feet; area, 2 square feet; discharge, 3.4 second-feet.

*Oak Creek near Naches, Wash.*—This stream is tributary to Tieton River. A measurement was made March 8, 1906, at medium stage:

Width, 7 feet; area, 8.2 square feet; discharge, 13 second-feet.

*Silver Creek near Easton, Wash.*—A measurement was made by floats at low water, April 23, 1906, at the mouth of canyon:

Width, 7 feet; area, 2.4 square feet; discharge, 3.4 second-feet.

*Taneum Creek near Thorp, Wash.*—A measurement was made at the highway bridge, 3 miles west of Thorp, March 19, 1906. The water surface was 4.17 feet below a spike in the downstream end of a 12-by-12 inch cap of bent at the left end of the bridge. The stream was at medium stage:

Width, 20 feet; area, 19 square feet; discharge, 22 second-feet.

*Yakima River at Easton, Wash.*—This station, which was discontinued November 28, 1904, is described in Water-Supply Paper No. 135, page 78. The following measurement was made March 16, 1906:

Width, 146 feet; area, 255 square feet; gage height, 5.30 feet; discharge, 585 second-feet.

*Yakima River near Sunnyside, Wash.*—A measurement was made at low water August 3, 1906, below Sunnyside dam:

Width, 70 feet; area, 65 square feet; discharge, 45 second-feet.

*Yakima River near Richland.*—A measurement was made at extreme low water August 17, 1906, 500 feet below the highway bridge.

Water surface 16.15 feet below spike marked "R. P." in downstream end of cap of first pile-pin at right abutment of bridge:

Width, 54 feet; area, 23 square feet; discharge, 29 second-feet.

## CANALS IN YAKIMA VALLEY, WASHINGTON.

Descriptions and discharge data of the canals in Yakima Valley are given in Water-Supply Paper No. 178, pages 52–78. Systematic observations of gage heights and discharge were discontinued on most of the canals during 1906.

### SUNNYSILE CANAL NEAR YAKIMA, WASH.

This canal heads on the left bank of Yakima River 5 miles below the town of Yakima. It is owned and operated by the United States Reclamation Service. Measurements are made from a footbridge 200 feet below the head gate. The gage is a vertical staff on the right bank.

*Discharge measurements of Sunnyside Canal near Yakima, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 22 | W. C. Muldrow | 30 | 17 | 0.70 | 14 |
| April 30 | do | 46 | 189 | 4.63 | 610 |
| June 25 | do | 45 | 193 | 4.80 | 606 |
| August 3 | do | 45 | 166 | 4.15 | 484 |
| September 19 | do | 45 | 150 | 3.80 | 416 |
| September 29 | Stevens and Grover | 45 | 153 | 3.85 | 410 |

*Daily gage height, in feet, of Sunnyside Canal near Yakima, Wash., for 1906.*

| Day. | Apr. | May. | June. | July. | Aug. | Sept. | Day. | Apr. | May. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.6 | 4.6 | 4.45 | 4.9 | 4.6 | 3.8 | 17 | 3.6 | 4.7 | 4.0 | 5.2 | 4.55 | 4.0 |
| 2 | .6 | 4.6 | 4.35 | 4.9 | 4.5 | 3.75 | 18 | 3.9 | 4.7 | 4.0 | 5.2 | 3.8 | 4.0 |
| 3 | .6 | 4.6 | 4.35 | 4.9 | 4.15 | 3.6 | 19 | 3.9 | 4.7 | 4.0 | 5.2 | 4.2 | 3.9 |
| 4 | .6 | 4.6 | 4.35 | 4.9 | 4.1 | 3.6 | 20 | 4.0 | 4.7 | 4.25 | 5.2 | 4.2 | 3.8 |
| 5 | 1.4 | 4.6 | 4.35 | 4.9 | 4.0 | 3.6 | 21 | 4.2 | 4.7 | 4.25 | 5.2 | 4.1 | 3.4 |
| 6 | 1.6 | 4.6 | 1.0 | 4.9 | 3.85 | 3.6 | 22 | 4.2 | 4.7 | 4.55 | 5.2 | 3.9 | 3.8 |
| 7 | 1.9 | 4.6 | 3.8 | 5.0 | 3.75 | 3.7 | 23 | 4.2 | 4.7 | 4.7 | 5.2 | 3.9 | 3.8 |
| 8 | 2.1 | 4.6 | 4.05 | 5.1 | 4.15 | 4.0 | 24 | 4.35 | 4.7 | 4.7 | 5.2 | 4.1 | 3.8 |
| 9 | 2.5 | 4.7 | 4.0 | 5.1 | 4.1 | 3.85 | 25 | 4.35 | 4.7 | 4.8 | 5.2 | 3.9 | 3.8 |
| 10 | 2.8 | 4.7 | 4.0 | 5.1 | 4.15 | 4.0 | 26 | 4.5 | 4.6 | 4.9 | 5.2 | 3.9 | 3.8 |
| 11 | 2.8 | 4.7 | 4.0 | 5.1 | 4.15 | 3.85 | 27 | 4.5 | 4.6 | 4.9 | 5.2 | 3.9 | 3.8 |
| 12 | 2.8 | 4.7 | 4.0 | 5.2 | 4.5 | 4.0 | 28 | 4.5 | 4.6 | 4.9 | 5.2 | 3.8 | 3.8 |
| 13 | 3.0 | 4.7 | 4.0 | 5.2 | 4.6 | 4.1 | 29 | 4.5 | 4.6 | 4.9 | 5.2 | 4.0 | 3.8 |
| 14 | 3.0 | 4.7 | 4.0 | 5.2 | 4.6 | 4.1 | 30 | 4.63 | 4.6 | 4.9 | 5.2 | 4.0 | 3.8 |
| 15 | 3.3 | 4.7 | 4.0 | 5.2 | 4.5 | 4.0 | 31 | ..... | 4.45 | ..... | 4.85 | 3.8 | ..... |
| 16 | 3.6 | 4.7 | 4.0 | 5.2 | 4.6 | 4.0 | | | | | | | |

*Rating table for Sunnyside Canal near Yakima, Wash., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.60 | 12 | 1.50 | 75 | 2.40 | 180 | 3.30 | 317 | 4.40 | 529 |
| 0.70 | 16 | 1.60 | 85 | 2.50 | 194 | 3.40 | 334 | 4.60 | 572 |
| 0.80 | 20 | 1.70 | 95 | 2.60 | 208 | 3.50 | 352 | 4.80 | 616 |
| 0.90 | 26 | 1.80 | 106 | 2.70 | 222 | 3.60 | 370 | 5.00 | 660 |
| 1.00 | 33 | 1.90 | 117 | 2.80 | 237 | 3.70 | 389 | 5.20 | 704 |
| 1.10 | 41 | 2.00 | 129 | 2.90 | 252 | 3.80 | 408 | | |
| 1.20 | 49 | 2.10 | 141 | 3.00 | 268 | 3.90 | 427 | | |
| 1.30 | 57 | 2.20 | 154 | 3.10 | 284 | 4.00 | 447 | | |
| 1.40 | 66 | 2.30 | 167 | 3.20 | 300 | 4.20 | 487 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is fairly well defined.

*Monthly discharge of Sunnyside Canal near Yakima, Wash., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| April | 579 | 12 | 318 | 18,900 |
| May | 594 | 540 | 583 | 35,800 |
| June | 638 | 33 | 499 | 29,700 |
| July | 704 | 627 | 684 | 42,100 |
| August | 572 | 398 | 476 | 29,300 |
| September | 467 | 334 | 414 | 24,600 |
| The period | | | | 180,000 |

NOTE.—Values are rated as good.

### NEW RESERVATION CANAL NEAR YAKIMA, WASH.

This canal heads on the right bank of Yakima River a short distance below Union Gap gaging station on Yakima River. It is owned and operated by the Indian Department for the irrigation of lands in the Yakima Indian Reservation. Measurements are made at the highway bridge 2,000 feet below head-gate. The gage is a vertical staff attached to the bridge.

*Discharge measurements of New Reservation Canal near Yakima, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 22 | J. C. Stevens | 38 | 21 | [a] 0.60 | 23 |
| June 29 | W. C. Muldrow | 40 | 149 | 3.55 | 255 |
| August 3 | do | 40 | 149 | 3.60 | 145 |
| August 7 | do | 40 | 121 | 3.00 | 86 |
| September 19 | do | 40 | 111 | 2.60 | 95 |
| November 5 | Muldrow and McGlashan | 40 | 53 | 1.29 | 53 |

[a] Gage height uncertain.

*Daily gage height, in feet, New Reservation Canal near Yakima, Wash., for 1906.*

| Day. | Apr. | May. | June. | Aug. | Sept. | Oct. | Day. | Apr. | May. | June. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1.9 | 2.3 | ..... | 2.6 | 2.6 | 17 | ..... | 2.3 | 2.3 | 2.8 | 2.6 | 2.6 |
| 2 | | 2.1 | 2.3 | 3.7 | 2.6 | 2.6 | 18 | ..... | 2.3 | 2.3 | 3.45 | 2.6 | 2.6 |
| 3 | | 2.2 | 2.4 | 3.6 | 2.6 | 2.6 | 19 | ..... | 2.2 | 2.3 | 2.6 | 2.6 | 1.3 |
| 4 | | 2.2 | 2.4 | 3.6 | 2.6 | 2.6 | 20 | ..... | 2.2 | .0 | 2.6 | 2.6 | 1.3 |
| 5 | | 2.2 | 2.5 | 3.6 | 2.6 | 2.6 | 21 | ..... | 2.3 | .0 | 2.6 | 2.6 | 1.3 |
| 6 | | 2.3 | .0 | 3.6 | 2.6 | 2.6 | 22 | 1.5 | 2.3 | 2.4 | 2.6 | 2.6 | 1.3 |
| 7 | | .0 | 2.3 | 2.9 | 2.6 | 2.6 | 23 | 1.7 | 2.4 | 2.7 | 2.6 | 2.6 | 1.3 |
| 8 | | 2.4 | .0 | 2.9 | 2.6 | 2.6 | 24 | 1.6 | 2.5 | 2.7 | 2.6 | 2.6 | 1.3 |
| 9 | | 2.4 | 2.2 | 2.0 | 2.6 | 2.6 | 25 | 1.6 | 2.5 | 2.9 | 2.6 | 2.6 | 1.3 |
| 10 | | 2.4 | 2.2 | 1.9 | 2.6 | 2.6 | 26 | 1.8 | 2.6 | 3.1 | 2.6 | 2.6 | 1.3 |
| 11 | | 2.5 | .0 | 1.9 | 2.6 | 2.6 | 27 | 1.6 | 2.5 | 3.4 | 2.6 | 2.6 | 1.3 |
| 12 | | 2.5 | 2.2 | 1.9 | 2.6 | 2.6 | 28 | 1.8 | 2.3 | 3.5 | 2.6 | 2.6 | 1.3 |
| 13 | | 2.4 | 2.1 | 1.9 | 2.6 | 2.6 | 29 | 1.8 | 2.3 | 3.6 | 2.6 | 2.6 | 1.3 |
| 14 | | 2.4 | 2.1 | 2.8 | 2.6 | 2.6 | 30 | 1.9 | 2.3 | 3.6 | 2.6 | 2.6 | 1.3 |
| 15 | | 2.5 | 2.3 | 2.8 | 2.6 | 2.6 | 31 | ..... | 2.3 | ..... | 2.6 | ..... | 1.3 |
| 16 | | 2.5 | 2.3 | 2.8 | 2.6 | 2.6 | | | | | | | |

NOTE.—The growth of certain water plants reduces the velocity of the canal as the season progresses, therefore there is not a constant relation between gage height and discharge.

### OLD RESERVATION CANAL NEAR WAPATO, WASH.

This canal takes water from the right bank of Yakima River, 4 miles below Wapato. It is owned and operated by the Indian Department for irrigation of lands in the Yakima Indian Reserva-

tion. Measurements are made from railroad bridge one-half mile below head-gate. The gage is a vertical staff at the railroad bridge.

*Discharge measurements of Old Reservation Canal near Wapato, Wash., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 22 | W. C. Muldrow | 11.5 | 5.6 | 0.45 | 4.6 |
| June 29 | do | 14.0 | 38 | 3.10 | 152 |
| August 3 | do | 11.8 | 22 | 1.75 | 65 |
| August 7 | do | 11.3 | 18 | 1.40 | 40 |
| September 19 | do | 11.3 | 22 | 1.85 | 65 |
| November 5 | H. D. McGlashan | 12.0 | 15 | 1.39 | 36 |

*Daily gage height, in feet, of Old Reservation Canal near Wapato, Wash., for 1906.*

| Day. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|
| 1 | | 3.2 | 3.1 | 3.0 | | 1.4 | 1.3 |
| 2 | | | 2.0 | 3.0 | | 1.4 | 1.3 |
| 3 | | | 2.0 | 3.0 | 1.75 | 1.4 | 1.3 |
| 4 | | 3.3 | 2.0 | 3.0 | 1.75 | 1.4 | 1.3 |
| 5 | | | 2.0 | 3.1 | 1.75 | 1.4 | 1.3 |
| 6 | | | 2.0 | 3.2 | 1.5 | 1.8 | 1.3 |
| 7 | | 3.1 | 2.0 | 3.1 | 1.4 | 1.8 | 1.3 |
| 8 | | | 2.0 | 3.2 | 1.45 | 1.8 | 1.3 |
| 9 | | | 2.0 | 3.1 | .8 | 1.8 | 1.3 |
| 10 | | | 2.0 | 3.0 | .8 | 1.8 | 1.3 |
| 11 | | 3.1 | 2.0 | 3.0 | .8 | 1.8 | 1.3 |
| 12 | | | 2.0 | 3.0 | .8 | 1.8 | 1.3 |
| 13 | | | 2.0 | 3.0 | .8 | 1.8 | 1.3 |
| 14 | | 3.2 | 2.0 | 3.0 | 1.7 | 1.8 | 1.3 |
| 15 | | 3.2 | 2.0 | 3.0 | 1.7 | 1.8 | 1.3 |
| 16 | | 3.2 | 2.0 | 3.0 | 1.7 | 1.8 | 1.3 |
| 17 | | 3.15 | 2.0 | 3.0 | 1.7 | 1.8 | 1.3 |
| 18 | | | 2.55 | 2.9 | 1.7 | 1.8 | 1.3 |
| 19 | | 3.2 | 3.3 | 2.9 | 1.7 | 1.8 | 1.3 |
| 20 | | 3.2 | 3.3 | 2.8 | 1.6 | 1.8 | 1.3 |
| 21 | | 3.2 | 3.3 | 2.8 | 1.6 | 1.8 | 1.3 |
| 22 | | 3.2 | 3.2 | 2.7 | 1.55 | 1.8 | 1.3 |
| 23 | | 3.2 | 3.2 | 2.6 | 1.55 | 1.8 | 1.3 |
| 24 | 3.1 | 3.2 | 3.1 | 2.6 | 1.4 | 1.8 | 1.3 |
| 25 | | 3.2 | 3.1 | 2.55 | 1.4 | 1.8 | 1.3 |
| 26 | 3.22 | 3.4 | 3.1 | 2.5 | 1.4 | 1.8 | 1.3 |
| 27 | | 3.4 | 3.1 | 2.5 | 1.4 | 1.8 | 1.3 |
| 28 | 3.2 | 3.5 | 3.0 | 2.4 | 1.4 | 1.8 | 1.3 |
| 29 | | 3.3 | 3.0 | 2.3 | 1.4 | 1.3 | 1.3 |
| 30 | | 3.3 | 3.0 | 2.2 | 1.4 | 1.3 | 1.3 |
| 31 | | 3.1 | | 2.1 | 1.4 | | 1.3 |

*Rating table for Old Reservation Canal near Wapato, Wash., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.50 | 6 | 1.20 | 31 | 1.90 | 70 | 2.60 | 117 | 3.30 | 163 |
| 0.60 | 9 | 1.30 | 36 | 2.00 | 77 | 2.70 | 124 | 3.40 | 170 |
| 0.70 | 12 | 1.40 | 41 | 2.10 | 83 | 2.80 | 131 | 3.50 | 177 |
| 0.80 | 15 | 1.50 | 46 | 2.20 | 89 | 2.90 | 138 | | |
| 0.90 | 18 | 1.60 | 52 | 2.30 | 96 | 3.00 | 145 | | |
| 1.00 | 22 | 1.70 | 58 | 2.40 | 103 | 3.10 | 152 | | |
| 1.10 | 26 | 1.80 | 64 | 2.50 | 110 | 3.20 | 159 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 6 discharge measurements made during 1906 and is well defined.

*Monthly discharge of Old Reservation Canal near Wapato, Wash., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| May | 177 | 152 | 159 | 9,780 |
| June | 163 | 77 | 112 | 6,660 |
| July | 159 | 83 | 133 | 8,180 |
| August | 75 | 15 | 45.5 | 2,800 |
| September | 64 | 36 | 58.3 | 3,470 |
| October | 36 | 36 | 36.0 | 2,210 |
| The period | | | | 33,100 |

NOTE.—Values are rated as good.

## MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made on canals in Yakima Valley, Washington, in 1906.

*Miscellaneous measurements of canals in Yakima River drainage basin, Washington, in 1906.*

| Date. | Canal. | Locality. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|
| | | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| August 6 | Bull | Head-gate, Ellensburg | 6 | 8.8 | 1.78 | 20 |
| March 19 | Cascade | Upper flume, Thorp | 8 | 6.4 | 0.80 | 22 |
| April 18 | Cowiche | 2 miles above Cowiche | 7 | 6.3 | | 11 |
| June 3 | do | Head-gate, Cowiche | 5 | 5.5 | | 12 |
| September 1 | do | do | 2 | 0.48 | | 0.26 |
| April 20 | Farmers ditch | Highway crossing, Tampico | 3.5 | 2.4 | | 4.1 |
| April 15 | Fortune | Foster's ranch | 5.7 | 2.3 | 0.45 | 1.4 |
| April 7 | Fowler | North Yakima | 9.7 | 5.3 | | 6.5 |
| April 22 | do | do | 9.7 | 9.7 | 0.70 | 27 |
| April 22 | Granger | do | 3.5 | 0.52 | | 0.45 |
| August 4[a] | Hatch | Toppenish | 6 | 4.2 | | 4 |
| April 7 | Hubbard | North Yakima | 13.1 | 17 | 1.30 | 12 |
| April 22 | do | do | 15 | 25 | 1.75 | 31 |
| April 22 | Moxee | do | 10 | 12 | 2.03 | 14 |
| August 16 | Old Union | North Yakima: | | | | |
| | | 2,000 feet below head-gate | 14 | 36 | 2.82 | 42 |
| | | At head-gate | 12.2 | 20 | 1.44 | 29 |
| | | do | 12.2 | 18 | 1.40 | 27 |
| | | do | 11.5 | 16 | 1.21 | 17 |
| | | do | 12.7 | 23 | 1.75 | 40 |
| | | 2,000 feet below head-gate | | | 2.65 | 29 |
| August 6 | Olsen | Ellensburg | 11 | 25 | 2.50 | 40 |
| May 17 | Prosser | Prosser | 6.5 | 12 | 2.12 | 18 |
| May 23 | Selah Valley | Natchez: | | | | |
| | | Wastegate No. 12 | 6.8 | 14 | | 56 |
| | | Above control gates | 8.5 | 26 | | 78 |
| | | Below control gates | 8.8 | 26 | 2.75 | 75 |
| | | At flume No. 8 | 8.0 | 20 | | 67 |
| | | At flume No. 23 | 6.8 | 17 | | 62 |
| | | At head-gate | 18.5 | 42 | 3.58 | 93 |
| April 20 | Shaw ditch | 1½ miles above Atanum | 14 | 10 | | 6.0 |
| April 20 | Stair ditch | 2 miles above Atanum | 4.5 | 2.5 | | 4.7 |
| March 19[b] | Taneum | Thorp | 10.5 | 5.9 | 0.57 | 11 |
| May 5 | Town | Ellensburg | 14 | 38 | 2.68 | 115 |
| August 6 | do | do | 14 | 40 | 2.85 | 125 |
| April 3 | do | North Yakima | 5.7 | 6 | 1.00 | 7.5 |
| April 3 | do | do | 5.7 | 6.2 | 1.08 | 8.3 |
| April 3 | do | do | 5.7 | 9.5 | 1.71 | 20 |
| April 15 | do | do | 5.7 | 7.5 | 1.26 | 11 |
| March 1 | Union | do | 11.5 | 11 | 0.98 | 9 |
| August 16 | do | Naches avenue, North Yakima | 6 | 13 | 2.52 | 33 |
| April 26 | Union Gap | North Yakima | 3.8 | 1.7 | 0.45 | 1.5 |
| August 9[c] | Wapaton | do | 2.0 | 54 | | 117 |
| April 5 | Yakima Valley (Congdon). | Head | 8.5 | 8.6 | 0.48 | 12 |

[a] Measured by floats.
[b] Water probably raised by ice gorge below.
[c] Three-fourths mile below head-gate.

## SNAKE RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Snake River, the largest tributary of the Columbia, rises among the high peaks of the Rocky Mountains in Yellowstone National Park, western Montana and eastern Wyoming, heading in the divide from which streams flow northward and eastward into the Missouri and southward and westward to the Colorado and the lakes of the Great Basin. From Shoshone, Lewis, and Hart lakes, in Yellowstone National Park, the south fork of the river flows southward, broadening into Jackson Lake (4 miles wide and 18 miles long) and passing through Jackson Valley (8 miles wide and 40 miles long), beyond which, near the Idaho-Wyoming line, it enters a long canyon. In the southern part of Fremont County, Idaho, it unites with North Fork. Below the junction of the forks it flows westward across Idaho to a point near Homedale, where it turns abruptly northward, forming for about 170 miles the boundary between Idaho and Oregon and for 30 miles more that between Idaho and Washington. At Lewiston it crosses into Washington, flows northwest, west, and southwest, and joins the Columbia at Pasco Junction.

Its upper drainage basin comprises the timbered mountainous country west and southwest of Yellowstone Lake. The east side of its valley is bounded by the Wind River Range, from the slopes of which it receives a number of tributaries, and the west side by the high Teton Mountains, from which most of the drainage flows westward through Teton River into North Fork.

Below the junction of North and South forks the Snake receives many important tributaries, among which may be mentioned Boise, Salmon, Clearwater, and Palouse rivers from the north and east and Owyhee, Malheur, Powder, and Grande Ronde rivers from the south and west.

The Owyhee, which joins the Snake at Owyhee, Oreg., drains a high, broken, timberless area, in portions of which the rainfall amounts to but 8 or 10 inches per annum. In many respects the drainage area of the Malheur is similar to that of the Owyhee, but parts of the headwater region are mountainous and rather heavily timbered. The drainage basin of the Grande Ronde, comprising the eastern slope of the Blue Mountains and the western slope of the Cornucopia Range in northeastern Oregon, is throughout mountainous and heavily timbered, and for much of its course the river occupies a deep canyon. Wallowa River, its principal tributary, closely resembles it. Grande Ronde Valley, a broadening of the Grande Ronde basin at the town of La Grande, and Wallowa Valley, a similar broadening of Wallowa River below the town of Joseph, are important agricultural areas within the Grande Ronde drainage basin. Powder and Palouse rivers and Asotin Creek drain areas similar in

character, utilized chiefly for dry farming and the production of wheat. The waters of all of these streams are valuable for irrigation, which in a number of the valleys—notably that of the Malheur—has reached a comparatively high stage of development. At Asotin a power plant is operated, and the waters used for power are also used for irrigation.

### NORTH FORK OF SNAKE RIVER NEAR ORA, IDAHO.

This station was established August 20, 1902. It is located at the North Fork Bridge, 2 miles south of Ora and 10 miles above St. Anthony, Idaho. The bench mark is a United States Geological Survey aluminum tablet set in a large rock about 30 feet northeast from the north end of the bridge; elevation, 12.84 feet above the gage datum.

The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 91, where are given also references to publications that contain data for previous years.

*Discharge measurements of North Fork of Snake River near Ora, Idaho, in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 11 | E. C. La Rue | 178 | 505 | 2.90 | 2,170 |
| May 27 | do | 178 | 470 | 2.70 | 1,900 |
| June 17 | do | 178 | 496 | 2.85 | 2,130 |

*Daily gage height, in feet, of North Fork of Snake River near Ora, Idaho, for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.0 | 2.0 | 2.0 | 1.9 | 3.3 | 2.9 | 2.5 | 2.1 | 2.1 | 2.0 | 2.1 |
| 2 | 2.0 | 2.0 | 2.0 | 1.9 | 3.3 | 2.9 | 2.5 | 2.1 | 2.1 | 2.0 | 2.1 |
| 3 | 2.0 | 2.0 | 2.0 | 1.9 | 3.3 | 2.8 | 2.5 | 2.1 | 2.1 | 2.0 | 2.1 |
| 4 | 2.0 | 1.9 | 2.0 | 1.9 | 3.3 | 2.9 | 2.4 | 2.1 | 2.0 | 2.0 | 2.1 |
| 5 | 2.0 | 1.9 | 1.9 | 1.9 | 3.1 | 3.0 | 2.4 | 2.1 | 2.0 | 2.0 | 2.1 |
| 6 | 2.0 | 1.9 | 1.9 | 1.9 | 3.1 | 3.2 | 2.4 | 2.1 | 2.0 | 2.0 | 2.1 |
| 7 | 2.0 | 1.9 | 1.9 | 1.9 | 2.9 | 3.2 | 2.4 | 2.1 | 2.0 | 2.0 | 2.1 |
| 8 | 2.0 | 2.0 | 1.9 | 2.0 | 2.9 | 3.1 | 2.4 | 2.1 | 2.0 | 2.1 | 2.1 |
| 9 | 2.0 | 2.0 | 1.9 | 2.0 | 2.9 | 3.0 | 2.4 | 2.1 | 2.1 | 2.1 | 2.1 |
| 10 | 2.0 | 2.0 | 1.9 | 2.0 | 2.8 | 2.9 | 2.4 | 2.0 | 2.1 | 2.1 | 2.1 |
| 11 | 2.0 | 2.0 | 1.9 | 2.1 | 2.8 | 2.9 | 2.4 | 2.0 | 2.1 | 2.1 | 2.1 |
| 12 | 2.0 | 2.0 | 1.9 | 2.1 | 2.8 | 2.8 | 2.3 | 2.0 | 2.1 | 2.1 | 2.1 |
| 13 | 2.0 | 2.0 | 1.9 | 2.1 | 2.8 | 2.8 | 2.3 | 2.0 | 2.1 | 2.1 | 2.1 |
| 14 | 2.0 | 2.0 | 1.9 | 2.1 | 2.9 | 2.8 | 2.3 | 2.0 | 2.2 | 2.1 | 2.1 |
| 15 | 2.0 | 2.0 | 1.9 | 2.1 | 2.9 | 2.8 | 2.3 | 2.0 | 2.2 | 2.1 | 2.1 |
| 16 | 2.0 | 2.0 | 1.9 | 2.1 | 2.9 | 2.7 | 2.3 | 2.0 | 2.2 | 2.1 | 2.1 |
| 17 | 2.0 | 2.0 | 1.9 | 2.2 | 2.8 | 2.8 | 2.3 | 2.0 | 2.2 | 2.1 | 2.1 |
| 18 | 2.0 | 2.0 | 1.9 | 2.2 | 2.8 | 2.8 | 2.3 | 2.1 | 2.2 | 2.1 | 2.0 |
| 19 | 2.0 | 2.0 | 1.9 | 2.2 | 2.7 | 2.7 | 2.3 | 2.1 | 2.1 | 2.1 | 2.0 |
| 20 | 2.0 | 2.0 | 1.9 | 2.2 | 2.7 | 2.7 | 2.3 | 2.1 | 2.1 | 2.1 | 2.0 |
| 21 | 2.0 | 2.0 | 2.0 | 2.2 | 2.7 | 2.6 | 2.3 | 2.1 | 2.1 | 2.1 | 2.0 |
| 22 | 2.0 | 2.0 | 2.0 | 2.5 | 2.6 | 2.6 | 2.2 | 2.2 | 2.1 | 2.1 | 2.0 |
| 23 | 2.0 | 2.0 | 2.0 | 2.5 | 2.6 | 2.6 | 2.2 | 2.2 | 2.1 | 2.1 | 2.0 |
| 24 | 2.0 | 2.0 | 2.0 | 2.8 | 2.6 | 2.6 | 2.2 | 2.2 | 2.1 | 2.1 | 2.0 |
| 25 | 2.0 | 2.0 | 2.0 | 3.0 | 2.7 | 2.5 | 2.2 | 2.2 | 2.1 | 2.1 | 2.0 |
| 26 | 2.0 | 2.0 | 2.0 | 3.0 | 2.7 | 2.5 | 2.2 | 2.2 | 2.1 | 2.1 | 2.0 |
| 27 | 2.0 | 2.0 | 2.0 | 3.1 | 2.7 | 2.5 | 2.2 | 2.2 | 2.1 | 2.1 | 2.0 |
| 28 | 2.0 | 2.0 | 1.9 | 3.2 | 2.7 | 2.5 | 2.2 | 2.1 | 2.1 | 2.1 | 2.0 |
| 29 | 2.0 | ..... | 1.9 | 3.3 | 2.9 | 2.5 | 2.2 | 2.1 | 2.1 | 2.1 | 2.0 |
| 30 | 2.0 | ..... | 1.9 | 3.3 | 3.1 | 2.5 | 2.1 | 2.1 | 2.2 | 2.1 | 2.0 |
| 31 | 2.0 | ..... | 1.9 | ..... | 3.0 | ..... | 2.1 | 2.1 | ..... | 2.1 | (a) |

a Record discontinued for the winter.

*Rating table for North Fork of Snake River near Ora, Idaho, for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.90 | 910 | 2.20 | 1,170 | 2.50 | 1,550 | 2.80 | 2,030 | 3.10 | 2,600 |
| 2.00 | 990 | 2.30 | 1,280 | 2.60 | 1,700 | 2.90 | 2,210 | 3.20 | 2,810 |
| 2.10 | 1,070 | 2.40 | 1,410 | 2.70 | 1,860 | 3.00 | 2,400 | 3.30 | 3,030 |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 8 discharge measurements made during 1905–6 and is well defined.

*Monthly discharge of North Fork of Snake River near Ora, Idaho, for 1906.*

[Drainage area, 1,040 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 990 | 990 | 990 | 60,900 | 0.952 | 1.10 |
| February | 990 | 910 | 979 | 54,400 | .942 | .98 |
| March | 990 | 910 | 938 | 57,700 | .902 | 1.04 |
| April | 3,030 | 910 | 1,430 | 85,300 | 1.38 | 1.54 |
| May | 3,030 | 1,700 | 2,200 | 135,000 | 2.11 | 2.43 |
| June | 2,810 | 1,550 | 2,000 | 119,000 | 1.92 | 2.14 |
| July | 1,550 | 1,070 | 1,300 | 79,800 | 1.25 | 1.44 |
| August | 1,170 | 990 | 1,070 | 65,700 | 1.03 | 1.19 |
| September | 1,170 | 990 | 1,080 | 64,100 | 1.04 | 1.16 |
| October | 1,070 | 990 | 1,050 | 64,700 | 1.01 | 1.16 |
| November | 1,070 | 990 | 1,030 | 61,600 | .995 | 1.11 |
| The period | | | | 848,000 | | |

NOTE.—Values are rated as excellent on the assumption that the flow was not affected by ice conditions, January to March.

## SNAKE RIVER NEAR MINIDOKA, IDAHO.

This station was originally established August 5, 1895, at Montgomery's ferry, on the stage road from Minidoka to Albion, 4 miles east of Rupert, Idaho, and 10 miles below the diversion dam for the Minidoka irrigation project. Measurements at Montgomery's ferry show the amount of water available for irrigation purposes there and for the newly constructed Twin Falls canals heading 23 miles below, and also the conditions that will exist for power purposes at Shoshone Falls, about 45 miles below, after the irrigable lands of Snake River Valley shall have been reclaimed. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 93, where are given also references to publications that contain data for previous years.

*Discharge measurements of Snake River near Minidoka, Idaho, in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 12 | E. C. La Rue | 815 | 4,020 | 3.15 | 6,120 |
| April 26 | do | 835 | 4,980 | 4.34 | 9,590 |
| May 19 | do | 860 | 6,610 | 6.29 | 16,100 |
| June 9 | do | 865 | 7,970 | 7.92 | 22,500 |

*Daily gage height, in feet, of Snake River near Minidoka, Idaho, in 1906.*

| Day. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 2.7 | 3.4 | 4.7 | 7.35 | 4.4 | 2.4 | 2.2 | 2.65 |
| 2 | (a) | 2.7 | 3.4 | 4.7 | 7.5 | 4.4 | 2.25 | 2.3 | 2.65 |
| 3 | 3.25 | 3.0 | 3.3 | 4.8 | 7.7 | 4.4 | 2.2 | 2.35 | 2.6 |
| 4 | 3.2 | 2.9 | 3.15 | 4.95 | 7.8 | 4.4 | 2.05 | 2.35 | 2.7 |
| 5 | 3.2 | 2.7 | 3.15 | 5.1 | 7.8 | 4.4 | 1.9 | 2.35 | 2.65 |
| 6 | 3.0 | 2.7 | 3.2 | 5.5 | 7.85 | 4.4 | 1.8 | 2.35 | 2.6 |
| 7 | 3.0 | 2.7 | 3.1 | 5.5 | 7.8 | 4.4 | 1.7 | .6 | 2.6 |
| 8 | 2.9 | 2.7 | 3.1 | 5.6 | 7.85 | 4.4 | 1.6 | .75 | 2.6 |
| 9 | 3.05 | 2.7 | 3.0 | 5.55 | 7.85 | 4.4 | 1.6 | 1.9 | 2.55 |
| 10 | 3.3 | 2.7 | 3.0 | 5.5 | 8.0 | 3.85 | 1.55 | 2.1 | 2.4 |
| 11 | 3.05 | 2.7 | 3.0 | 5.4 | 8.0 | 3.35 | 1.5 | 2.1 | 2.35 |
| 12 | 2.7 | 2.7 | 3.1 | 5.4 | 7.95 | 3.3 | 1.5 | 2.1 | 2.35 |
| 13 | 2.4 | 2.65 | 3.25 | 5.5 | 7.85 | 3.3 | 1.45 | 2.1 | 2.4 |
| 14 | 2.2 | 2.6 | 3.25 | 5.55 | 7.7 | 3.2 | 1.45 | 2.1 | 2.4 |
| 15 | 2.35 | 2.5 | 3.25 | 5.75 | 7.9 | 3.2 | 1.45 | 2.1 | 2.4 |
| 16 | 2.5 | 2.35 | 3.3 | 5.9 | 8.0 | 3.2 | 1.45 | 2.1 | 2.6 |
| 17 | 2.6 | 2.45 | 3.2 | 6.1 | 8.15 | 3.4 | 1.45 | 2.1 | 2.95 |
| 18 | 2.6 | 2.9 | 3.2 | 6.25 | 8.2 | 4.8 | 1.45 | 2.15 | 2.9 |
| 19 | 2.6 | 2.8 | 3.2 | 6.3 | 8.3 | 5.2 | 1.45 | 2.2 | 3.2 |
| 20 | 2.65 | 2.55 | 3.25 | 6.3 | 8.3 | 5.1 | 1.45 | 2.2 | 3.4 |
| 21 | 2.7 | 2.4 | 3.45 | 6.25 | 8.1 | 5.1 | 1.45 | 2.25 | 3.6 |
| 22 | 2.7 | 2.35 | 3.6 | 6.2 | 7.8 | 5.0 | 1.5 | 2.25 | 3.5 |
| 23 | 2.7 | 2.5 | 3.7 | 6.15 | 7.5 | 4.75 | 1.5 | 2.25 | 3.35 |
| 24 | 2.75 | 2.6 | 4.0 | 6.2 | 7.25 | 4.6 | 1.5 | 2.3 | 3.25 |
| 25 | 2.75 | 2.8 | 4.2 | 6.2 | 6.85 | 4.4 | 1.5 | 2.4 | 3.2 |
| 26 | 2.75 | 3.05 | 4.3 | 6.2 | 6.6 | 4.15 | 2.1 | 2.7 | 3.2 |
| 27 | 2.7 | 3.2 | 4.45 | 6.2 | 6.35 | 4.9 | 2.45 | 2.7 | 3.15 |
| 28 | 2.7 | 3.3 | 4.65 | 6.45 | 6.05 | 3.7 | 2.6 | 2.7 | 3.1 |
| 29 | ..... | 3.3 | 4.7 | 6.55 | 5.4 | 3.45 | 2.55 | 2.7 | 3.05 |
| 30 | ..... | 3.4 | 4.7 | 6.8 | 4.75 | 3.1 | 2.2 | 2.65 | 3.0 |
| 31 | ..... | 3.4 | ..... | 7.05 | ..... | 2.7 | 2.2 | ..... | (b) |

[a] River frozen over January 1 to February 2, 1906.
[b] Gates at Minidoka dam were closed during November. Records at gaging station were unreliable November 1 to December 31.

*Rating table for Snake River near Minidoka, Idaho, for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.60 | 1,640 | 1.70 | 2,670 | 2.70 | 4,930 | 3.70 | 7,630 | 5.40 | 12,950 |
| .70 | 1,680 | 1.80 | 2,860 | 2.80 | 5,180 | 3.80 | 7,920 | 5.60 | 13,670 |
| .80 | 1,720 | 1.90 | 3,060 | 2.90 | 5,440 | 3.90 | 8,210 | 5.80 | 14,390 |
| .90 | 1,760 | 2.00 | 3,270 | 3.00 | 5,700 | 4.00 | 8,500 | 6.00 | 15,110 |
| 1.00 | 1,820 | 2.10 | 3,480 | 3.10 | 5,970 | 4.20 | 9,080 | 6.20 | 15,830 |
| 1.10 | 1,880 | 2.20 | 3,700 | 3.20 | 6,240 | 4.40 | 9,680 | 6.40 | 16,550 |
| 1.20 | 1,960 | 2.30 | 3,940 | 3.30 | 6,510 | 4.60 | 10,280 | 6.60 | 17,270 |
| 1.30 | 2,060 | 2.40 | 4,180 | 3.40 | 6,780 | 4.80 | 10,890 | 6.80 | 18,010 |
| 1.40 | 2,190 | 2.50 | 4,430 | 3.50 | 7,060 | 5.00 | 11,540 | 7.00 | 18,790 |
| 1.50 | 2,340 | 2.60 | 4,680 | 3.60 | 7,340 | 5.20 | 12,230 | 8.00 | 23,010 |
| 1.60 | 2,500 | | | | | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 11 discharge measurements made during 1905–6 and is well defined above 2.3 feet; below that it is uncertain.

*Monthly discharge of Snake River near Minidoka, Idaho, for 1906.*

[Drainage area, 17,900[a] square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec. ft. per sq. mile. | Depth in inches. |
| February (3-28) | 6,510 | 3,700 | 5,150 | 265,000 | 0.288 | 0.28 |
| March | 6,780 | 4,060 | 5,130 | 316,000 | .287 | .33 |
| April | 10,600 | 5,700 | 7,150 | 425,000 | .399 | .44 |
| May | 19,000 | 10,600 | 14,500 | 892,000 | .810 | .93 |
| June | 24,300 | 10,700 | 20,900 | 1,250,000 | 1.17 | 1.30 |
| July | 12,200 | 4,930 | 8,870 | 546,000 | .496 | .57 |
| August | 4,680 | 2,260 | 2,900 | 178,000 | .162 | .19 |
| September | 4,930 | 1,640 | 3,770 | 225,000 | .211 | .23 |
| October | 7,340 | 4,060 | 5,320 | 317,000 | .297 | .33 |
| The period | ..... | ..... | ..... | 4,410,000 | ..... | ..... |

[a] Exclusive of drainage of Big and Little Lost rivers.

NOTE.—Values are rated as follows: February to July, and October, excellent; August and September, good.

## SNAKE RIVER BETWEEN MILNER DAM AND SHOSHONE FALLS, DURING NOVEMBER, 1906.

The following is a brief report of investigations in regard to the source and volume of flow in Snake River between the Milner dam, Milner, Idaho, and Shoshone Falls, Idaho, dating from November 14 to 22 (inclusive), 1906, when the flow was entirely cut off at the Minidoka dam.

The flow at this time below the Milner dam was derived from leakage through the gates at the dam, waste water from the Twin Falls tract, and springs along its course. In no case did water flow over the Milner dam and the waste from the Twin Falls tract was at a minimum

In passing down the river from Milner to Shoshone Falls, discharge measurements were made as often as suitable stations could be found. All springs of appreciable size entering between Milner and Shoshone Falls lie between Shoshone Falls and a point 6 miles above. Most of them enter on the north side. The source of these springs is not definitely known. Upon them will depend the permanent flow of Snake River over Shoshone Falls at future times if all the water is diverted above for irrigation, with no waste.

The following is a tabulation of the measurements taken:

*Measurements between Milner Dam and Shoshone Falls in 1906.*

| Date. | Location. | | Discharge. | Date. | Location. | | Discharge. |
|---|---|---|---|---|---|---|---|
| | Above Shoshone Falls. | Below Milner. | | | Above Shoshone Falls. | Below Milner. | |
| | *Feet.* | *Miles.* | *Sec.-ft.* | | *Feet.* | *Miles.* | *Sec.-ft.* |
| November 14 | 1,500 | ..... | 195 | November 18 | ..... | 6 | 20 |
| November 15 | 1,500 | ..... | 165 | November 18 | ..... | 7 | 27 |
| November 16 | 1,500 | ..... | 158 | November 20 | ..... | 16 | 60 |
| November 17 | ..... | 2 | 22 | November 21 | 1,500 | ..... | 169 |
| November 18 | ..... | 4 | 17 | November 22 | 1,500 | ..... | 200 |

During the investigation the minimum flow measured at Shoshone Falls was 158 second-feet. The measurements made between the Milner dam and a point 7 miles below show that about 30 second-feet come from leakage through the Milner dam and waste from the Twin Falls tract; there then remains 128 second-feet as the gain in discharge between Milner dam and Shoshone Falls. Just what part of this is spring water and what part drains from pools can not be determined. Throughout the course there are a great many pools from 200 feet to 1 mile in length. No doubt it would take considerable time for these pools to drain down to a normal stage.

There is but one conclusion to be drawn and that is that the permanent flow over Shoshone Falls during the irrigation season, when the water is all diverted above, will be reduced to approximately 130 second-feet or less.

## SNAKE RIVER AT NEELEY, IDAHO.

On March 17, 1906, a temporary station was established at Neeley, Idaho, 3 miles above the backwater from the Minidoka dam and 4 miles below American Falls. This station is to eventually take the place of the old Montgomery station below the Minidoka dam. During 1906 only gage readings were taken. The station will be rated at some future time.

*Daily gage height, in feet, of Snake River at Neeley, Idaho, for 1906.*

| Day. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 5.3 | 6.8 | 9.8 | 6.65 | ..... | 4.9 | ..... | 4.9 | 5.0 |
| 2 | ..... | 5.25 | 7.0 | 9.7 | 6.5 | 4.2 | 4.8 | ..... | 4.9 | 5.0 |
| 3 | ..... | 5.25 | 7.5 | 9.65 | 6.4 | ..... | 4.65 | ..... | 4.9 | 5.0 |
| 4 | ..... | 5.2 | 7.1 | 9.4 | 6.5 | 4.0 | 4.5 | 4.6 | 5.0 | 5.0 |
| 5 | ..... | 5.15 | 7.15 | 9.4 | 6.65 | 4.0 | 4.5 | 4.6 | 5.0 | 5.0 |
| 6 | ..... | 5.15 | 7.35 | 9.3 | 6.7 | 3.9 | 4.6 | 4.6 | 5.0 | (a) |
| 7 | ..... | 5.1 | 7.6 | 9.5 | 6.6 | 3.8 | 6.5 | 4.7 | 5.0 | ..... |
| 8 | ..... | 5.05 | 7.4 | 9.7 | 6.5 | 3.8 | 6.3 | 4.7 | 5.0 | ..... |
| 9 | ..... | 5.05 | 7.25 | 9.75 | 6.4 | 3.75 | 5.0 | 4.7 | 5.0 | ..... |
| 10 | ..... | 5.1 | 7.15 | 9.5 | 6.4 | 3.7 | 4.3 | 4.7 | 5.0 | ..... |
| 11 | ..... | 5.25 | 7.1 | 9.3 | 6.3 | 3.7 | 4.3 | 4.7 | 5.0 | ..... |
| 12 | ..... | 5.4 | 7.4 | 9.0 | 6.3 | 3.7 | 4.35 | 4.7 | 5.0 | ..... |
| 13 | ..... | 5.35 | 7.65 | 9.1 | 6.3 | 3.7 | 4.4 | 4.7 | 5.0 | ..... |
| 14 | ..... | 5.3 | 7.85 | 9.5 | 6.3 | 3.7 | 4.5 | 4.7 | 5.0 | ..... |
| 15 | ..... | 5.15 | 8.2 | 9.7 | 6.3 | 3.7 | 4.5 | 4.8 | 5.0 | ..... |
| 16 | ..... | 5.1 | 8.5 | 10.0 | 6.3 | 3.7 | 4.5 | 4.8 | 5.0 | ..... |
| 17 | 4.55 | 5.2 | 8.6 | 9.85 | 6.2 | 3.7 | 4.6 | 4.8 | 5.0 | ..... |
| 18 | 4.55 | 5.3 | 8.7 | 9.75 | 6.1 | 3.7 | 4.7 | 4.8 | 5.0 | ..... |
| 19 | 4.55 | 5.4 | 8.3 | 9.65 | 6.0 | 3.7 | 4.75 | 4.8 | 5.0 | ..... |
| 20 | 4.6 | 5.45 | 8.0 | 9.5 | 6.0 | 3.65 | 4.8 | 4.8 | 5.0 | ..... |
| 21 | 4.65 | 5.8 | 7.6 | 8.9 | 5.9 | 3.65 | 4.8 | 4.8 | 5.0 | ..... |
| 22 | 4.7 | 5.95 | 7.75 | 8.0 | 5.8 | 3.65 | 4.8 | 4.8 | 5.0 | ..... |
| 23 | 4.7 | 6.05 | 7.9 | 7.7 | 5.7 | 3.7 | 4.7 | 4.9 | 5.0 | ..... |
| 24 | 4.95 | 6.35 | 7.8 | 7.5 | 5.6 | 3.8 | 4.7 | 4.9 | 5.0 | ..... |
| 25 | 5.2 | 6.7 | 7.95 | 7.3 | 5.5 | 4.1 | 4.7 | 4.9 | 5.0 | ..... |
| 26 | 5.35 | 6.9 | 8.1 | 7.0 | 5.4 | 4.6 | 4.7 | 4.9 | 5.0 | ..... |
| 27 | 5.6 | 6.85 | 8.65 | 6.7 | 5.2 | 4.95 | 4.7 | 4.9 | 5.0 | ..... |
| 28 | 5.45 | 6.8 | 9.2 | 6.6 | ..... | 4.95 | 4.6 | 4.9 | 5.0 | ..... |
| 29 | 5.35 | 6.75 | 9.4 | 6.5 | ..... | 4.95 | 4.6 | 4.9 | 5.0 | ..... |
| 30 | 5.35 | 6.65 | 9.5 | 6.7 | ..... | 4.95 | 4.6 | 4.9 | 5.0 | ..... |
| 31 | 5.45 | ..... | 9.9 | ..... | ..... | 4.9 | ..... | 4.9 | ..... | ..... |

(a) Record discontinued for the winter.

## FALL RIVER AT FREMONT, IDAHO.

This station was established January 1, 1904, about 900 feet from Fremont post-office. During 1906 the gage was read once each day by Mrs. Eva A. Loomis and C. R. Scheetz. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 97, where are given also references to publications that contain data for previous years.

*Discharge measurements of Fall River at Fremont, Idaho, in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 11 | E. C. La Rue | 147 | 362 | 3.25 | 1,640 |
| May 27 | do | 148 | 369 | 3.32 | 1,690 |
| June 17 | do | 149 | 448 | 3.85 | 2,510 |
| August 17 | do | 140 | 184 | 2.02 | 468 |

*Daily gage height, in feet, of Fall River at Fremont, Idaho, for 1906.*

| Day. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 2.8 | 3.5 | 3.1 | 1.9 | 1.9 | 1.9 | 1.9 |
| 2 | ..... | 2.1 | 3.6 | 3.2 | 2.0 | 1.9 | 1.9 | 1.9 |
| 3 | ..... | 2.1 | 3.55 | 3.0 | 2.05 | 1.9 | 1.95 | 1.9 |
| 4 | ..... | 2.1 | 3.4 | 3.0 | 2.05 | 1.9 | 1.95 | 1.9 |
| 5 | ..... | 2.9 | 3.85 | 3.1 | 2.0 | 1.95 | 1.95 | 1.9 |
| 6 | (a) | 2.1 | 3.95 | 3.3 | 2.0 | 1.8 | 1.95 | 1.9 |
| 7 | 1.9 | 2.1 | 3.8 | 3.1 | 2.0 | 1.9 | 1.9 | 1.9 |
| 8 | 1.9 | 2.1 | 3.65 | 3.0 | 2.0 | 1.9 | 1.9 | 1.9 |
| 9 | 1.9 | 3.0 | 3.3 | 3.0 | 2.0 | 1.9 | 1.9 | 1.9 |
| 10 | 1.9 | 3.0 | 3.0 | 3.1 | 2.0 | 1.9 | 1.9 | 1.9 |
| 11 | 1.9 | 3.1 | 3.4 | 3.1 | 2.0 | 1.9 | 1.9 | 1.9 |
| 12 | 1.9 | 3.2 | 3.3 | 3.0 | 2.0 | 1.9 | 1.9 | 1.9 |
| 13 | 1.9 | 3.1 | 3.55 | 2.9 | 2.0 | 1.9 | 1.95 | 1.9 |
| 14 | 1.9 | 3.3 | 3.65 | 2.8 | 2.05 | 1.95 | 1.95 | 1.9 |
| 15 | 1.9 | 3.8 | 3.5 | 2.6 | 2.05 | 2.05 | 1.95 | 1.9 |
| 16 | 1.9 | 3.4 | 3.3 | 2.6 | 2.0 | 1.95 | 1.95 | 1.9 |
| 17 | 2.0 | 2.9 | 3.95 | 2.6 | 2.0 | 1.9 | 1.95 | 1.9 |
| 18 | 2.05 | 2.85 | 3.55 | 2.5 | 2.0 | 1.9 | 1.95 | (b) |
| 19 | 2.1 | 2.95 | 3.3 | 2.3 | 2.05 | 1.9 | 1.95 | ..... |
| 20 | 2.1 | 2.1 | 3.1 | 2.3 | 2.05 | 1.9 | 1.95 | ..... |
| 21 | 2.15 | 2.1 | 3.0 | 2.5 | 2.0 | 1.9 | 1.9 | ..... |
| 22 | 2.25 | 3.0 | 3.0 | 2.4 | 2.0 | 1.9 | 1.9 | ..... |
| 23 | 2.45 | 3.1 | 3.0 | 2.3 | 2.1 | 1.95 | 1.9 | ..... |
| 24 | 2.65 | 3.4 | 3.0 | 2.2 | 2.15 | 1.9 | 1.9 | ..... |
| 25 | 2.6 | 3.65 | 3.0 | 2.3 | 2.05 | 1.9 | 1.9 | ..... |
| 26 | 2.5 | 3.5 | 2.9 | 2.3 | 2.0 | 1.9 | 1.9 | ..... |
| 27 | 2.5 | 3.5 | 3.1 | 2.2 | 2.05 | 1.9 | 1.9 | ..... |
| 28 | 2.55 | 3.55 | 3.25 | 2.0 | 2.0 | 1.9 | 1.9 | ..... |
| 29 | 2.7 | 3.6 | 3.0 | 1.9 | 1.9 | 1.9 | 1.9 | ..... |
| 30 | 2.8 | 3.45 | 3.3 | 1.9 | 1.9 | 1.9 | 1.9 | ..... |
| 31 | ..... | 3.5 | ..... | 2.0 | 1.9 | ..... | 1.9 | ..... |

(a) No record on account of ice January 1 to April 6, 1906.
(b) Record discontinued for the winter on November 18.

*Rating table for Fall River at Fremont, Idaho, for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.40 | 168 | 2.00 | 485 | 2.60 | 945 | 3.20 | 1,565 | 3.80 | 2,345 |
| 1.50 | 210 | 2.10 | 555 | 2.70 | 1,035 | 3.30 | 1,685 | 3.90 | 2,495 |
| 1.60 | 255 | 2.20 | 625 | 2.80 | 1,125 | 3.40 | 1,815 | 4.00 | 2,655 |
| 1.70 | 305 | 2.30 | 700 | 2.90 | 1,225 | 3.50 | 1,945 | | |
| 1.80 | 365 | 2.40 | 775 | 3.00 | 1,335 | 3.60 | 2,075 | | |
| 1.90 | 425 | 2.50 | 860 | 3.10 | 1,445 | 3.70 | 2,205 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 8 discharge measurements made during 1905–6 and is well defined.

*Monthly discharge of Fall River at Fremont, Idaho, for 1906.*

[Drainage area, 390 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| April 7–30 | 1,120 | 425 | 631 | 30,000 | 1.62 | 1.45 |
| May | 2,340 | 555 | 1,350 | 83,200 | 3.47 | 4.00 |
| June | 2,580 | 1,220 | 1,780 | 105,800 | 4.56 | 5.09 |
| July | 1,680 | 425 | 1,010 | 62,300 | 2.60 | 3.00 |
| August | 590 | 425 | 492 | 30,200 | 1.26 | 1.45 |
| September | 520 | 365 | 430 | 25,600 | 1.10 | 1.23 |
| October | 455 | 425 | 437 | 26,900 | 1.12 | 1.29 |
| November 1–17 | 425 | 425 | 425 | 14,300 | 1.09 | .69 |
| The period | | | | 378,000 | | |

NOTE.—Values are rated as follows: May to July, excellent; April and August to November, good.

## TETON RIVER NEAR ST. ANTHONY, IDAHO.

This station was established April 23, 1903. It is located at the bridge on the stage road from St. Anthony to Victor, Idaho. The bench mark is a United States Geological Survey aluminum tablet set in solid rock about 30 feet northeast of the north end of the bridge; elevation, 13.53 feet above the gage datum. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 99, where are given also references to publications that contain data for previous years.

*Discharge measurements of Teton River near St. Anthony, Idaho, in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 12 | E. C. La Rue | 79.5 | 438 | 3.20 | 1,640 |
| May 28 | do | 79.5 | 477 | 3.65 | 2,100 |
| June 18 | do | 79.5 | 498 | 3.90 | 2,270 |
| August 13 | do | 79.5 | 350 | 1.95 | 646 |

*Daily gage height, in feet, of Teton River near St. Anthony, Idaho, for 1906.*

| Day. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1.3 | 1.6 | 2.0 | 3.65 | 2.65 | 2.05 | 1.8 | 1.75 | 1.7 | 1.6 |
| 2 | | 1.35 | 1.5 | 2.1 | 3.55 | 2.8 | 2.05 | 1.75 | 1.75 | 1.7 | 1.6 |
| 3 | | 1.35 | 1.6 | 2.15 | 3.5 | 2.95 | 2.05 | 1.75 | 1.85 | 1.7 | 1.7 |
| 4 | | 1.3 | 1.6 | 2.3 | 3.9 | 3.0 | 2.05 | 1.75 | 1.85 | 1.7 | 1.8 |
| 5 | | 1.35 | 1.65 | 2.4 | 3.1 | 3.0 | 2.1 | 1.8 | 1.8 | 1.7 | 1.8 |
| 6 | | 1.35 | 1.7 | 2.3 | 4.25 | 2.95 | 2.05 | 1.8 | 1.8 | 1.75 | 1.7 |
| 7 | | 1.3 | 1.9 | 2.25 | 4.1 | 2.95 | 2.05 | 1.8 | 1.75 | 1.75 | 1.65 |
| 8 | | 1.3 | 2.0 | 2.3 | 3.8 | 2.85 | 2.05 | 1.8 | 1.75 | 1.65 | 1.6 |
| 9 | | 1.3 | 2.1 | 2.5 | 3.5 | 2.95 | 2.05 | 1.8 | 1.7 | 1.65 | (a) |
| 10 | | 1.3 | 2.15 | 2.85 | 3.45 | 2.85 | 2.0 | 1.8 | 1.7 | 1.65 | ..... |
| 11 | | 1.1 | 2.2 | 3.0 | 3.9 | 2.8 | 2.0 | 1.8 | 1.7 | 1.65 | ..... |
| 12 | | 1.0 | 2.15 | 3.3 | 4.25 | 2.75 | 1.9 | 1.8 | 1.7 | 1.65 | ..... |
| 13 | | 1.2 | 2.1 | 3.4 | 4.9 | 2.75 | 1.9 | 1.8 | 1.7 | 1.65 | ..... |
| 14 | | 1.3 | 2.0 | 3.6 | 4.95 | 2.7 | 1.85 | 1.85 | 1.75 | 1.65 | ..... |
| 15 | | 1.4 | 2.1 | 3.85 | 4.35 | 2.65 | 1.85 | 1.95 | 1.75 | 1.6 | ..... |
| 16 | | 1.2 | 2.25 | 3.7 | 4.2 | 2.6 | 1.85 | 2.0 | 1.7 | 1.6 | ..... |
| 17 | | 1.2 | 2.45 | 3.2 | 4.15 | 2.6 | 1.85 | 2.0 | 1.75 | 1.6 | ..... |
| 18 | | 1.1 | 2.35 | 2.85 | 3.9 | 2.6 | 1.8 | 1.9 | 1.75 | 1.6 | ..... |
| 19 | 1.3 | 1.1 | 2.15 | 2.6 | 3.45 | 2.55 | 1.85 | 1.9 | 1.75 | 1.65 | ..... |
| 20 | 1.3 | 1.1 | 2.1 | 2.8 | 3.0 | 2.5 | 1.9 | 1.8 | 1.75 | 1.7 | ..... |
| 21 | 1.25 | 1.1 | 2.0 | 3.0 | 2.9 | 2.35 | 1.95 | 1.8 | 1.75 | 1.65 | ..... |
| 22 | 1.3 | 1.2 | 2.1 | 3.1 | 2.95 | 2.4 | 1.9 | 1.8 | 1.7 | 1.6 | ..... |
| 23 | 1.3 | 1.25 | 2.2 | 2.95 | 2.9 | 2.4 | 1.95 | 1.8 | 1.7 | 1.65 | ..... |
| 24 | 1.3 | 1.3 | 2.3 | 3.15 | 2.8 | 2.4 | 2.0 | 1.8 | 1.7 | 1.65 | ..... |
| 25 | 1.3 | 1.3 | 2.35 | 4.1 | 2.65 | 2.3 | 2.0 | 1.8 | 1.7 | 1.6 | ..... |
| 26 | 1.3 | 1.35 | 2.15 | 4.5 | 2.7 | 2.25 | 2.0 | 1.8 | 1.7 | 1.6 | ..... |
| 27 | 1.35 | 1.35 | 2.0 | 3.95 | 2.7 | 2.2 | 1.95 | 1.75 | 1.7 | 1.6 | ..... |
| 28 | 1.35 | 1.4 | 1.9 | 3.6 | 2.75 | 2.1 | 1.9 | 1.75 | 1.7 | 1.6 | ..... |
| 29 | ..... | 1.5 | 1.9 | 3.95 | 2.9 | 2.1 | 1.9 | 1.75 | 1.7 | 1.6 | ..... |
| 30 | ..... | 1.6 | 1.95 | 3.1 | 2.65 | 2.1 | 1.85 | 1.75 | 1.7 | 1.6 | ..... |
| 31 | ..... | 1.65 | ..... | 3.8 | ..... | 2.1 | 1.8 | ..... | 1.7 | ..... | ..... |

(a) Discontinued for the winter.

*Rating table for Teton River near St. Anthony, Idaho, for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.00 | 88 | 1.80 | 548 | 2.60 | 1,100 | 3.40 | 1,755 | 4.40 | 3,045 |
| 1.10 | 142 | 1.90 | 610 | 2.70 | 1,177 | 3.50 | 1,850 | 4.60 | 3,385 |
| 1.20 | 197 | 2.00 | 674 | 2.80 | 1,255 | 3.60 | 1,950 | 4.80 | 3,740 |
| 1.30 | 253 | 2.10 | 740 | 2.90 | 1,335 | 3.70 | 2,060 | 5.00 | 4,115 |
| 1.40 | 310 | 2.20 | 808 | 3.00 | 1,417 | 3.80 | 2,175 | | |
| 1.50 | 368 | 2.30 | 878 | 3.10 | 1,500 | 3.90 | 2,300 | | |
| 1.60 | 427 | 2.40 | 950 | 3.20 | 1,584 | 4.00 | 2,435 | | |
| 1.70 | 487 | 2.50 | 1,024 | 3.30 | 1,669 | 4.20 | 2,730 | | |

NOTE.—The above table is strictly applicable only for open-channel conditions. It is based on 14 discharge measurements made during 1904–1906 and is well defined above gage height 1.5 feet.

*Monthly discharge of Teton River near St. Anthony, Idaho, for 1906.*

[Drainage area, 960 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| February 19–28 | 281 | 225 | 256 | 5,080 | 0.267 | 0.10 |
| March | 457 | 88 | 247 | 15,200 | .257 | .30 |
| April | 987 | 368 | 690 | 41,100 | .719 | .80 |
| May | 3,220 | 674 | 1,520 | 93,700 | 1.59 | 1.83 |
| June | 4,020 | 1,140 | 2,010 | 119,000 | 2.09 | 2.33 |
| July | 1,420 | 740 | 1,100 | 67,400 | 1.14 | 1.31 |
| August | 740 | 548 | 643 | 39,500 | .670 | .77 |
| September | 674 | 517 | 557 | 33,100 | .580 | .65 |
| October | 579 | 487 | 508 | 31,200 | .529 | .61 |
| November | 517 | 427 | 456 | 27,100 | .475 | .53 |
| December 1–8 | 548 | 427 | 476 | 7,550 | .496 | .15 |
| The period | | | | 480,000 | | |

NOTE.—Values are rated as follows: February and March, good; April to December, excellent.

## SOUTH FORK OF SNAKE RIVER AT MORAN, WYO.

This station was established September 21, 1903. It is located directly back of the post-office at Moran, Wyo., and about three-fourths mile below the outlet of Jackson Lake. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 101, where are given also references to publications that contain data for previous years.

*Discharge measurements of South Fork of Snake River at Moran, Wyo., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| June 19 | R. J. Newell | 202 | 1,190 | 5.52 | 5,740 |
| June 24 | ....do | 202 | 1,030 | 4.70 | 4,290 |
| August 25 | E. C. La Rue | 198 | 520 | 1.85 | 962 |

*Daily gage height, in feet, of South Fork of Snake River at Moran, Wyo., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.0 | 1.2 | 1.25 | 1.2 | 1.7 | 4.7 | 4.4 | 2.7 | 1.7 | 1.25 |
| 2 | 1.0 | 1.2 | 1.25 | 1.2 | 1.75 | 4.7 | 4.3 | 2.65 | 1.7 | 1.25 |
| 3 | 1.0 | 1.2 | 1.2 | 1.2 | 1.8 | 4.7 | 4.3 | 2.6 | 1.65 | 1.25 |
| 4 | 1.0 | 1.15 | 1.2 | 1.2 | 1.85 | 4.6 | 4.25 | 2.5 | 1.65 | 1.25 |
| 5 | 1.0 | 1.15 | 1.2 | 1.2 | 1.9 | 4.4 | 4.25 | 2.5 | 1.65 | 1.2 |
| 6 | 1.0 | 1.15 | 1.2 | 1.2 | 1.95 | 4.6 | 4.25 | 2.45 | 1.65 | 1.2 |
| 7 | 1.0 | 1.1 | 1.2 | 1.2 | 2.0 | 4.8 | 4.25 | 2.4 | 1.65 | 1.2 |
| 8 | 1.0 | 1.1 | 1.2 | 1.2 | 2.05 | 4.75 | 4.25 | 2.35 | 1.65 | 1.2 |
| 9 | .9 | 1.1 | 1.2 | 1.2 | 2.15 | 4.7 | 4.25 | 2.15 | 1.6 | 1.15 |
| 10 | .9 | 1.1 | 1.2 | 1.2 | 2.25 | 4.8 | 4.25 | 1.95 | 1.6 | 1.15 |
| 11 | .9 | 1.15 | 1.2 | 1.2 | 2.35 | 4.85 | 4.2 | 1.95 | 1.55 | 1.1 |
| 12 | .9 | 1.15 | 1.2 | 1.2 | 2.55 | 4.9 | 4.2 | 1.9 | 1.55 | 1.1 |
| 13 | .9 | 1.15 | 1.2 | 1.2 | 2.8 | 5.0 | 3.95 | 1.9 | 1.5 | (a) |
| 14 | .9 | 1.15 | 1.2 | 1.2 | 3.15 | 5.1 | 3.95 | 1.95 | 1.5 | ..... |
| 15 | .9 | 1.15 | 1.2 | 1.2 | 3.45 | 5.25 | 3.8 | 1.95 | 1.45 | ..... |
| 16 | .9 | 1.15 | 1.2 | 1.2 | 3.55 | 5.65 | 3.85 | 1.9 | 1.45 | ..... |
| 17 | 1.0 | 1.15 | 1.2 | 1.2 | 3.6 | 5.65 | 3.7 | 1.85 | 1.4 | ..... |
| 18 | 1.0 | 1.15 | 1.2 | 1.2 | 3.6 | 5.65 | 3.65 | 1.8 | 1.4 | ..... |
| 19 | 1.1 | 1.2 | 1.2 | 1.2 | 3.65 | 5.45 | 3.6 | 1.8 | 1.4 | ..... |
| 20 | 1.1 | 1.2 | 1.2 | 1.2 | 3.7 | 5.2 | 3.5 | 1.8 | 1.4 | ..... |
| 21 | 1.15 | 1.2 | 1.2 | 1.2 | 3.8 | 5.1 | 3.55 | 1.8 | 1.4 | ..... |
| 22 | 1.15 | 1.2 | 1.2 | 1.25 | 3.95 | 4.9 | 3.4 | 1.85 | 1.4 | ..... |
| 23 | 1.2 | 1.2 | 1.2 | 1.3 | 4.1 | 4.8 | 3.35 | 1.85 | 1.35 | ..... |
| 24 | 1.2 | 1.2 | 1.2 | 1.3 | 4.25 | 4.65 | 3.2 | 1.85 | 1.35 | ..... |
| 25 | 1.2 | 1.2 | 1.2 | 1.35 | 4.5 | 4.55 | 3.2 | 1.85 | 1.3 | ..... |
| 26 | 1.2 | 1.2 | 1.2 | 1.4 | 4.6 | 4.5 | 3.1 | 1.85 | 1.3 | ..... |
| 27 | 1.2 | 1.2 | 1.2 | 1.45 | 4.65 | 4.45 | 2.95 | 1.85 | 1.3 | ..... |
| 28 | 1.2 | 1.2 | 1.2 | 1.5 | 4.8 | 4.45 | 2.8 | 1.8 | 1.3 | ..... |
| 29 | 1.2 | ..... | 1.2 | 1.6 | 5.0 | 4.4 | 2.8 | 1.8 | 1.3 | ..... |
| 30 | 1.2 | ..... | 1.2 | 1.65 | 5.0 | 4.35 | 2.8 | 1.75 | 1.3 | ..... |
| 31 | 1.2 | ..... | 1.2 | ..... | 4.85 | ..... | 2.75 | 1.75 | ..... | ..... |

(a) Water shut off of Jackson Lake Dam October 13 to December 24, 1906.

*Rating table for South Fork of Snake River at Moran, Wyo., for 1904–1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.80 | 330 | 1.90 | 1,007 | 3.00 | 1,967 | 4.10 | 3,280 | 5.20 | 5,080 |
| 0.90 | 374 | 2.00 | 1,084 | 3.10 | 2,070 | 4.20 | 3,420 | 5.30 | 5,265 |
| 1.00 | 422 | 2.10 | 1,163 | 3.20 | 2,175 | 4.30 | 3,565 | 5.40 | 5,450 |
| 1.10 | 474 | 2.20 | 1,244 | 3.30 | 2,285 | 4.40 | 3,715 | 5.50 | 5,640 |
| 1.20 | 530 | 2.30 | 1,327 | 3.40 | 2,400 | 4.50 | 3,870 | 5.60 | 5,830 |
| 1.30 | 590 | 2.40 | 1,412 | 3.50 | 2,515 | 4.60 | 4,030 | 5.70 | 6,025 |
| 1.40 | 653 | 2.50 | 1,499 | 3.60 | 2,635 | 4.70 | 4,195 | 5.80 | 6,220 |
| 1.50 | 719 | 2.60 | 1,588 | 3.70 | 2,760 | 4.80 | 4,365 | | |
| 1.60 | 788 | 2.70 | 1,679 | 3.80 | 2,885 | 4.90 | 4,540 | | |
| 1.70 | 859 | 2.80 | 1,772 | 3.90 | 3,015 | 5.00 | 4,720 | | |
| 1.80 | 932 | 2.90 | 1,868 | 4.00 | 3,145 | 5.10 | 4,900 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 9 discharge measurements made during 1903–1906 and is well defined.

*Monthly discharge of South Fork of Snake River at Moran, Wyo., for 1906.*

[Drainage area, 820 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 530 | 374 | 449 | 27,600 | 0.548 | 0.63 |
| February | 530 | 474 | 511 | 28,380 | .623 | .65 |
| March | 560 | 530 | 532 | 32,700 | .649 | .75 |
| April | 823 | 530 | 572 | 34,000 | .698 | .78 |
| May | 4,720 | 859 | 2,450 | 151,000 | 2.99 | 3.45 |
| June | 5,930 | 3,640 | 4,480 | 267,000 | 5.46 | 6.09 |
| July | 3,720 | 1,720 | 2,820 | 173,000 | 3.44 | 3.97 |
| August | 1,680 | 895 | 1,120 | 68,800 | 1.36 | 1.57 |
| September | 859 | 590 | 708 | 42,100 | .863 | .96 |
| October 1–12 | 560 | 474 | 526 | 12,500 | .641 | .29 |
| The period | ..... | ..... | ..... | 837,000 | ..... | ..... |

NOTE.—Values are rated as follows: January to April, September, and October, good; May to August, excellent. Flow assumed unaffected by ice conditions.

## SOUTH FORK OF SNAKE RIVER NEAR LYON, IDAHO.

This station was established April 18, 1903. It is located on the old site of Wedekind's Ferry, between Lyon and Swan Valley, at the upper end of Conant Valley. It is about 45 miles from Idaho Falls, Idaho. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 103, where are given also references to publications that contain data for previous years.

*Discharge measurements of South Fork of Snake River near Lyon, Idaho, in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 21 | E. C. La Rue | 292 | 2,370 | 5.80 | 15,900 |
| June 11 | do | 295 | 2,580 | 6.45 | 19,500 |
| June 12 | do | 299 | 2,670 | 6.85 | 20,600 |

*Daily gage height, in feet, of South Fork of Snake River near Lyon, Idaho, for 1906.*

| Day. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1.05 | 0.95 | 3.5 | 6.55 | 5.25 | 3.35 | 2.2 | 1.65 | 1.25 |
| 2 | | 1.05 | 1.1 | 3.5 | 6.3 | 5.6 | 3.25 | 2.2 | 1.6 | 1.2 |
| 3 | | 1.0 | 1.1 | 3.7 | 6.2 | 5.7 | 3.25 | 2.1 | 1.6 | 1.2 |
| 4 | | .9 | .95 | 4.3 | 6.35 | 5.7 | 3.2 | 2.1 | 1.65 | 1.25 |
| 5 | | .8 | .9 | 4.4 | 6.65 | 5.6 | 3.1 | 2.05 | 1.65 | 1.25 |
| 6 | | .7 | .9 | 4.0 | 6.9 | 5.65 | 3.05 | 2.05 | 1.6 | 1.2 |
| 7 | | .7 | .95 | 3.85 | 6.7 | 5.6 | 3.0 | 2.0 | 1.6 | 1.2 |
| 8 | | .7 | 1.2 | 4.0 | 6.3 | 5.5 | 2.9 | 2.0 | 1.6 | 1.2 |
| 9 | | .7 | 1.35 | 4.3 | 6.1 | 5.4 | 2.8 | 2.0 | 1.55 | 1.2 |
| 10 | | .7 | 1.45 | 4.65 | 6.1 | 5.35 | 2.7 | 2.0 | 1.55 | 1.2 |
| 11 | | .7 | 1.5 | 5.0 | 6.4 | 5.3 | 2.6 | 1.95 | 1.55 | 1.2 |
| 12 | | .4 | 1.6 | 5.2 | 7.0 | 5.2 | 2.5 | 1.95 | 1.5 | 1.2 |
| 13 | | .4 | 1.5 | 5.55 | 7.7 | 5.15 | 2.55 | 1.9 | 1.55 | 1.2 |
| 14 | | .6 | 1.5 | 6.15 | 7.9 | 5.2 | 2.55 | 1.95 | 1.5 | 1.5 |
| 15 | | .6 | 1.6 | 6.4 | 7.6 | 5.0 | 2.5 | 2.0 | 1.45 | 1.7 |
| 16 | | .6 | 1.8 | 6.2 | 7.5 | 4.8 | 2.4 | 1.95 | 1.4 | 1.55 |
| 17 | | .5 | 2.1 | 5.5 | 7.4 | 4.7 | 2.35 | 1.9 | 1.4 | 1.4 |
| 18 | (a) | .5 | 2.4 | 5.15 | 7.1 | 4.7 | 2.35 | 1.9 | 1.3 | 1.2 |
| 19 | 1.7 | .7 | 2.5 | 5.05 | 6.6 | 4.65 | 2.4 | 1.85 | 1.3 | 1.1 |
| 20 | 1.3 | .7 | 2.6 | 5.35 | 6.2 | 4.4 | 2.5 | 1.85 | 1.25 | .9 |
| 21 | 1.4 | .8 | 2.85 | 5.8 | 6.0 | 4.3 | 2.6 | 1.8 | 1.2 | .9 |
| 22 | 1.4 | .8 | 3.2 | 5.7 | 6.0 | 4.3 | 2.8 | 1.8 | 1.2 | .65 |
| 23 | 1.3 | .8 | 3.6 | 5.7 | 5.95 | 4.3 | 2.9 | 1.75 | 1.3 | .55 |
| 24 | 1.2 | .8 | 3.7 | 6.35 | 5.65 | 4.2 | 2.85 | 1.75 | 1.25 | .75 |
| 25 | 1.15 | .9 | 3.55 | 7.2 | 5.5 | 4.05 | 2.7 | 1.75 | 1.3 | .9 |
| 26 | 1.1 | .9 | 3.2 | 7.15 | 5.4 | 3.9 | 2.6 | 1.7 | 1.3 | .9 |
| 27 | 1.1 | .9 | 3.0 | 6.9 | 5.5 | 3.8 | 2.5 | 1.7 | 1.25 | .8 |
| 28 | 1.05 | .9 | 3.0 | 7.25 | 5.7 | 3.65 | 2.4 | 1.7 | 1.25 | .75 |
| 29 | | .9 | 3.2 | 7.55 | 5.55 | 3.5 | 2.3 | 1.65 | 1.25 | .75 |
| 30 | | .9 | 3.5 | 7.15 | 5.2 | 3.4 | 2.3 | 1.65 | 1.25 | .6 |
| 31 | | .95 | ..... | 6.9 | ..... | 3.3 | 2.2 | ..... | 1.25 | (b) |

a Frozen over, January 1 to February 18.
b December 1, record discontinued for the winter.

*Rating table for South Fork of Snake River near Lyon, Idaho, for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.40 | 1,700 | 1.50 | 3,000 | 2.60 | 5,090 | 3.70 | 7,850 | 5.40 | 14,160 |
| 0.50 | 1,800 | 1.60 | 3,155 | 2.70 | 5,310 | 3.80 | 8,150 | 5.60 | 15,010 |
| 0.60 | 1,900 | 1.70 | 3,320 | 2.80 | 5,530 | 3.90 | 8,450 | 5.80 | 15,900 |
| 0.70 | 2,005 | 1.80 | 3,495 | 2.90 | 5,750 | 4.00 | 8,760 | 6.00 | 16,830 |
| 0.80 | 2,115 | 1.90 | 3,680 | 3.00 | 5,980 | 4.20 | 9,420 | 6.20 | 17,790 |
| 0.90 | 2,225 | 2.00 | 3,870 | 3.10 | 6,220 | 4.40 | 10,150 | 6.40 | 18,760 |
| 1.00 | 2,340 | 2.10 | 4,065 | 3.20 | 6,470 | 4.60 | 10,920 | 6.60 | 19,750 |
| 1.10 | 2,460 | 2.20 | 4,265 | 3.30 | 6,730 | 4.80 | 11,710 | 6.80 | 20,750 |
| 1.20 | 2,585 | 2.30 | 4,465 | 3.40 | 7,000 | 5.00 | 12,520 | 7.00 | 21,760 |
| 1.30 | 2,715 | 2.40 | 4,670 | 3.50 | 7,208 | 5.20 | 13,340 | 8.00 | 27,060 |
| 1.40 | 2,855 | 2.50 | 4,880 | 3.60 | 7,560 | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1906 and is well defined.

*Monthly discharge of South Fork of Snake River near Lyon, Idaho, for 1906.*

[Drainage area, 5,480 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| February (19–28) | 3,320 | 2,400 | 2,690 | 53,300 | 0.491 | 0.18 |
| March | 2,400 | 1,700 | 2,080 | 128,000 | .379 | .44 |
| April | 7,850 | 2,220 | 4,300 | 256,000 | .786 | .88 |
| May | 24,600 | 7,280 | 14,900 | 915,000 | 2.72 | 3.14 |
| June | 26,500 | 13,300 | 18,900 | 1,120,000 | 3.44 | 3.84 |
| July | 15,400 | 6,720 | 11,700 | 718,000 | 2.13 | 2.46 |
| August | 6,860 | 4,260 | 5,320 | 327,000 | .970 | 1.12 |
| September | 4,240 | 3,240 | 3,700 | 220,000 | .675 | .75 |
| October | 3,240 | 2,580 | 2,890 | 178,000 | .528 | .61 |
| November | 3,320 | 1,850 | 2,470 | 147,000 | .450 | .50 |
| The period | | | | 4,070,000 | | |

NOTE.—Values for 1906 are excellent.

## BUFFALO RIVER NEAR ELK, WYO.

On July 31, 1906, a temporary station was established at the wagon bridge on Buffalo River, 300 feet above its junction with South Fork of Snake River.

The gage is a vertical staff nailed to the middle pier of the bridge and was read by the Government engineers during the construction of the temporary dam at Jackson Lake.

*Discharge measurements of Buffalo River near Elk, Wyo., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| August 14 | W. G. Davies | 74 | 218 | 4.43 | 352 |
| August 25 | E. C. La Rue | 74.5 | 199 | 4.48 | 370 |

*Daily gage height, in feet, of Buffalo River near Elk, Wyo., in 1906.*

| Day. | July. | Aug. | Sept. | Oct. | Nov. | Day. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 4.8 | 4.15 | 4.0 | 3.9 | 17 | ..... | 4.3 | 4.1 | 3.9 | 4.0 |
| 2 | ..... | 4.75 | 4.15 | 4.0 | 3.9 | 18 | ..... | 4.25 | 4.1 | 4.0 | 4.0 |
| 3 | ..... | 4.75 | 4.1 | 4.0 | 3.9 | 19 | ..... | 4.35 | 4.1 | 4.0 | 4.0 |
| 4 | ..... | 4.8 | 4.1 | 4.0 | 3.9 | 20 | ..... | 4.45 | 4.1 | 4.0 | 4.0 |
| 5 | ..... | 4.7 | 4.1 | 4.0 | 3.9 | 21 | ..... | 4.5 | 4.1 | 4.0 | (a) |
| 6 | ..... | 4.6 | 4.1 | 4.0 | 3.9 | 22 | ..... | 4.55 | 4.1 | 4.0 | ..... |
| 7 | ..... | 4.6 | 4.1 | 4.0 | 3.9 | 23 | ..... | 4.6 | 4.1 | 4.0 | ..... |
| 8 | ..... | 4.55 | 4.1 | 4.0 | 3.9 | 24 | ..... | 4.55 | 4.1 | 4.0 | ..... |
| 9 | ..... | 4.5 | 4.1 | 4.0 | 3.9 | 25 | ..... | 4.5 | 4.1 | 3.9 | ..... |
| 10 | ..... | 4.4 | 4.05 | 3.9 | 3.9 | 26 | ..... | 4.4 | 4.0 | 3.9 | ..... |
| 11 | ..... | 4.4 | 4.05 | 3.9 | 4.0 | 27 | ..... | 4.35 | 4.0 | 3.9 | ..... |
| 12 | ..... | 4.45 | 4.05 | 3.9 | 4.0 | 28 | ..... | 4.3 | 4.0 | 3.9 | ..... |
| 13 | ..... | 4.5 | 4.1 | 3.9 | 4.0 | 29 | ..... | 4.25 | 4.0 | 3.9 | ..... |
| 14 | ..... | 4.5 | 4.1 | 3.9 | 4.0 | 30 | ..... | 4.2 | 4.0 | 3.9 | ..... |
| 15 | ..... | 4.4 | 4.1 | 3.9 | 4.0 | 31 | 4.8 | 4.2 | ..... | 3.9 | ..... |
| 16 | ..... | 4.3 | 4.1 | 3.9 | 4.0 | | | | | | |

[a] Record discontinued for the winter.

## PACIFIC CREEK NEAR MORAN, WYO.

On July 31, 1906, a temporary station was established at the wagon bridge on Pacific Creek, 500 feet above its junction with South Fork of Snake River.

The gage is a vertical staff nailed to the right abutment pier of the bridge. The gage readings were taken by the Government engineers during the construction of the temporary storage dam at Jackson Lake.

*Discharge measurements of Pacific Creek near Moran, Wyo., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec. ft.* |
| August 14 | W. G. Davies | 31 | 90 | 6.45 | 96 |
| August 25 | E. C. La Rue | 29 | 77 | 6.60 | 103 |

*Daily gage height, in feet, of Pacific Creek near Moran, Wyo., for 1906.*

| Day. | Aug. | Sept. | Oct. | Nov. | Day. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.65 | 6.3 | 6.2 | 6.15 | 17 | ..... | 6.35 | 6.3 | 6.2 |
| 2 | 6.65 | 6.3 | 6.2 | 6.15 | 18 | ..... | 6.3 | 6.3 | 6.25 |
| 3 | 6.7 | 6.3 | 6.15 | 6.15 | 19 | ..... | 6.4 | 6.3 | 6.25 |
| 4 | 6.8 | 6.3 | 6.15 | 6.15 | 20 | ..... | 6.5 | 6.3 | 6.25 |
| 5 | 6.7 | 6.3 | 6.15 | 6.15 | 21 | ..... | 6.5 | 6.3 | 6.2 |
| 6 | 6.6 | 6.3 | 6.15 | 6.15 | 22 | ..... | 6.6 | 6.3 | 6.2 |
| 7 | 6.6 | 6.3 | 6.15 | 6.15 | 23 | ..... | 6.65 | 6.25 | 6.2 |
| 8 | 6.6 | 6.3 | 6.1 | 6.15 | 24 | ..... | 6.65 | 6.25 | 6.2 |
| 9 | 6.55 | 6.3 | 6.1 | 6.15 | 25 | ..... | 6.55 | 6.25 | 6.2 |
| 10 | 6.5 | 6.3 | 6.1 | 6.15 | 26 | ..... | 6.5 | 6.25 | 6.2 |
| 11 | 6.45 | 6.25 | 6.1 | 6.15 | 27 | ..... | 6.45 | 6.25 | 6.2 |
| 12 | 6.45 | 6.25 | 6.05 | (a) | 28 | ..... | 6.45 | 6.2 | 6.2 |
| 13 | 6.45 | 6.3 | 6.05 | ..... | 29 | ..... | 6.4 | 6.2 | 6.2 |
| 14 | 6.45 | 6.3 | 6.05 | ..... | 30 | ..... | 6.35 | 6.2 | 6.2 |
| 15 | 6.4 | 6.3 | 6.1 | ..... | 31 | 6.7 | 6.35 | ..... | 6.2 |
| 16 | 6.35 | 6.3 | 6.15 | ..... | | | | | |

[a] Record discontinued for the winter.

## BLACKFOOT RIVER NEAR PRESTO, IDAHO.

This station was established April 17, 1903. It is located on the ranch of James Just, 2 miles west of Presto and about 15 miles from Blackfoot, Idaho. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 106, where are given also references to publications that contain data for previous years.

*Discharge measurements of Blackfoot River near Presto, Idaho, in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 6 | E. C. La Rue | 56 | 293 | 4.06 | 939 |
| May 20 | do | 56 | 288 | 4.04 | 932 |
| June 10 | do | 56 | 254 | 3.40 | 759 |
| August 5 | do | 53 | 111 | .05 | 94 |

*Daily gage height, in feet, of Blackfoot River near Presto, Idaho, for 1906.*

| Day. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 0.8 | 4.45 | 4.1 | 1.2 | 0.1 | 0.5 | 0.75 | 1.0 |
| 2 | ..... | .85 | 4.3 | 4.15 | 1.2 | .05 | .45 | .75 | .95 |
| 3 | ..... | .8 | 4.2 | 4.05 | 1.25 | .05 | .5 | .8 | 1.0 |
| 4 | ..... | .9 | 4.15 | 4.1 | 1.2 | .05 | .5 | .75 | 1.0 |
| 5 | ..... | .95 | 4.15 | 4.1 | 1.15 | .05 | .5 | .8 | 1.05 |
| 6 | ..... | .9 | 4.05 | 3.95 | 1.1 | .05 | .7 | .8 | 1.05 |
| 7 | ..... | .9 | 4.0 | 3.75 | 1.0 | .0 | .6 | .8 | .95 |
| 8 | 0.7 | .85 | 3.9 | 3.6 | .95 | .0 | .6 | .8 | .95 |
| 9 | .8 | .9 | 3.65 | 3.5 | .9 | .05 | .55 | .75 | 1.0 |
| 10 | .6 | .7 | 3.4 | 3.35 | .9 | .1 | .55 | .7 | 1.0 |
| 11 | .7 | .95 | 3.15 | 3.2 | .9 | .1 | .5 | .8 | 1.0 |
| 12 | .7 | 1.0 | 3.0 | 3.0 | .7 | .15 | .55 | .8 | 1.1 |
| 13 | .6 | .9 | 2.75 | 2.7 | .65 | .4 | .6 | .8 | 1.05 |
| 14 | .6 | .95 | 2.9 | 2.5 | .65 | .2 | .6 | .9 | 1.0 |
| 15 | .7 | 1.4 | 3.45 | 2.35 | .6 | .2 | .55 | .8 | 1.05 |
| 16 | .8 | 1.5 | 3.75 | 2.2 | .5 | .2 | .5 | .85 | 1.05 |
| 17 | .8 | 1.7 | 3.55 | 2.05 | .55 | .25 | .6 | .9 | 1.1 |
| 18 | .9 | 1.95 | 3.7 | 2.0 | .55 | .3 | .6 | .85 | 1.15 |
| 19 | .8 | 2.5 | 4.0 | 2.0 | .4 | .35 | 7 | .85 | 1.1 |
| 20 | .75 | 2.85 | 4.1 | 1.85 | .35 | .3 | .75 | .9 | 1.3 |
| 21 | .7 | 3.3 | 3.8 | 1.7 | .3 | .3 | .75 | .9 | 1.45 |
| 22 | .7 | 4.1 | 3.55 | 1.8 | .2 | 35 | .75 | 1.0 | 1.4 |
| 23 | .9 | 5.1 | 3.3 | 1.75 | .15 | .3 | .8 | .95 | 1.5 |
| 24 | 1.7 | 5.5 | 2.9 | 1.7 | .15 | .3 | .8 | 1.0 | 1.6 |
| 25 | .85 | 5.5 | 2.95 | 1.55 | .15 | .35 | .7 | .9 | 1.6 |
| 26 | .7 | 5.35 | 2.8 | 1.5 | .1 | .4 | .65 | .9 | 1.55 |
| 27 | .75 | 5.1 | 2.9 | 1.4 | .15 | .45 | .65 | .95 | 1.6 |
| 28 | .8 | 5.0 | 3.3 | 1.4 | .1 | .45 | .7 | .9 | 1.6 |
| 29 | .8 | 4.7 | 3.55 | 1.25 | .1 | .5 | .7 | .9 | 1.9 |
| 30 | .75 | 4.5 | 3.7 | 1.15 | .1 | .5 | .7 | .9 | 1.9 |
| 31 | .9 | ..... | 3.8 | ..... | .1 | .5 | ..... | .95 | ..... |

*Rating table for Blackfoot River near Presto, Idaho, for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.00 | 59 | 0.90 | 182 | 1.80 | 345 | 2.70 | 548 | 4.20 | 995 |
| .10 | 70 | 1.00 | 199 | 1.90 | 365 | 2.80 | 573 | 4.40 | 1,070 |
| .20 | 82 | 1.10 | 216 | 2.00 | 386 | 2.90 | 598 | 4.60 | 1,150 |
| .30 | 94 | 1.20 | 233 | 2.10 | 407 | 3.00 | 624 | 4.80 | 1,250 |
| .40 | 107 | 1.30 | 251 | 2.20 | 429 | 3.20 | 679 | 5.00 | 1,350 |
| .50 | 121 | 1.40 | 269 | 2.30 | 451 | 3.40 | 738 | 5.20 | 1,450 |
| .60 | 135 | 1.50 | 287 | 2.40 | 474 | 3.60 | 798 | 5.40 | 1,570 |
| .70 | 150 | 1.60 | 306 | 2.50 | 498 | 3.80 | 858 | | |
| .80 | 166 | 1.70 | 325 | 2.60 | 523 | 4.00 | 925 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904–1906 and is well defined.

*Monthly discharge of Blackfoot River near Presto, Idaho, for 1906.*

[Drainage area, 1,020 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| March 8–31 | 325 | 135 | 165 | 7,860 | 0.162 | 0.14 |
| April | 1,630 | 150 | 593 | 35,300 | .584 | .65 |
| May | 1,090 | 560 | 801 | 49,200 | .788 | .91 |
| June | 977 | 224 | 551 | 32,800 | .542 | .60 |
| July | 242 | 70 | 139 | 8,550 | .137 | .16 |
| August | 121 | 59 | 87 | 5,350 | .086 | .10 |
| September | 166 | 114 | 138 | 8,210 | .136 | .15 |
| October | 199 | 150 | 174 | 10,700 | .171 | .20 |
| November | 365 | 190 | 240 | 14,300 | .236 | .26 |
| The period | | | | 172,000 | | |

NOTE.—Values are rated as follows: April to June, excellent; March, July, and September to November, good; August, fair.

## BIG LOST RIVER NEAR MACKAY, IDAHO.

This station was established November 12, 1903, and was discontinued September 1, 1906. It is located 3½ miles above Mackay, Idaho, above "The Narrows." The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 108, where are given also references to publications that contain data for previous years.

*Discharge measurements of Big Lost River near Mackay, Idaho, in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 21 | E. C. La Rue | 36 | 84 | 2.60 | 140 |
| May 8 | do | 38 | 105 | 3.17 | 267 |
| May 24 | do | 42 | 134 | 3.95 | 498 |
| June 14 | do | 90 | 298 | 6.25 | 1,470 |
| August 7 | do | 40 | 108 | 3.20 | 324 |

*Daily gage height, in feet, of Big Lost River near Mackay, Idaho, for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. |
|---|---|---|---|---|---|---|---|---|
| 1 | 2.7 | 2.65 | 2.65 | 2.65 | 2.65 | 4.1 | 4.7 | 3.5 |
| 2 | 2.7 | 2.65 | 2.65 | 2.65 | 2.65 | 4.05 | 4.65 | 3.5 |
| 3 | 2.7 | 2.65 | 2.65 | 2.65 | 2.65 | 4.0 | 5.05 | 3.45 |
| 4 | 2.7 | 2.65 | 2.65 | 2.65 | 2.65 | 4.2 | 5.3 | 3.4 |
| 5 | 2.7 | 2.65 | 2.6 | 2.65 | 2.8 | 4.6 | 5.4 | 3.3 |
| 6 | 2.7 | 2.65 | 2.6 | 2.65 | 2.9 | 4.6 | 5.6 | 3.25 |
| 7 | 2.7 | 2.65 | 2.6 | 2.7 | 3.1 | 4.5 | 5.5 | 3.15 |
| 8 | 2.7 | 2.65 | 2.6 | 2.7 | 3.3 | 4.25 | 5.4 | 3.1 |
| 9 | 2.7 | 2.65 | 2.6 | 2.7 | 3.55 | 4.2 | 5.4 | 3.05 |
| 10 | 2.7 | 2.65 | 2.6 | 2.7 | 3.8 | 4.15 | 5.2 | 3.0 |
| 11 | 2.7 | 2.65 | 2.6 | 2.7 | 4.3 | 5.3 | 5.1 | 2.95 |
| 12 | 2.7 | 2.65 | 2.6 | 2.7 | 4.5 | 5.8 | 5.1 | 2.95 |
| 13 | 2.7 | 2.65 | 2.6 | 2.7 | 4.7 | 5.8 | 5.6 | 3.2 |
| 14 | 2.7 | 2.65 | 2.6 | 2.7 | 4.65 | 6.2 | 5.65 | 3.15 |
| 15 | 2.7 | 2.65 | 2.6 | 2.65 | 4.7 | 5.8 | 5.5 | 3.05 |
| 16 | 2.7 | 2.65 | 2.6 | 2.65 | 4.6 | 5.7 | 5.1 | 3.0 |
| 17 | 2.7 | 2.65 | 2.6 | 2.65 | 4.4 | 5.5 | 4.9 | 3.0 |
| 18 | 2.7 | 2.65 | 2.6 | 2.65 | 4.25 | 5.4 | 4.85 | 3.0 |
| 19 | 2.7 | 2.65 | 2.6 | 2.65 | 4.0 | 5.3 | 4.6 | 2.95 |
| 20 | 2.7 | 2.65 | 2.6 | 2.65 | 4.0 | 5.2 | 4.5 | 2.95 |
| 21 | 2.7 | 2.65 | 2.6 | 2.65 | 4.1 | 5.2 | 4.4 | 2.95 |
| 22 | 2.7 | 2.65 | 2.6 | 2.65 | 4.0 | 5.2 | 4.35 | 3.2 |
| 23 | 2.7 | 2.65 | 2.6 | 2.65 | 3.95 | 5.1 | 4.2 | 3.4 |
| 24 | 2.7 | 2.65 | 2.6 | 2.65 | 3.95 | 4.85 | 4.05 | 3.4 |
| 25 | 2.7 | 2.65 | 2.6 | 2.65 | 4.0 | 4.7 | 3.9 | 3.4 |
| 26 | 2.7 | 2.65 | 2.6 | 2.65 | 4.1 | 4.9 | 3.75 | 3.35 |
| 27 | 2.7 | 2.65 | 2.65 | 2.65 | 4.4 | 5.1 | 3.65 | 3.3 |
| 28 | 2.7 | 2.65 | 2.65 | 2.65 | 4.4 | 5.25 | 3.6 | 3.2 |
| 29 | 2.7 | ..... | 2.65 | 2.65 | 4.4 | 5.0 | 3.55 | 3.1 |
| 30 | 2.7 | ..... | 2.65 | 2.65 | 4.25 | 4.7 | 3.5 | 3.0 |
| 31 | 2.65 | ..... | 2.65 | ..... | 4.1 | ..... | 3.5 | 3.0 |

*Rating table for Big Lost River near Mackay, Idaho, for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.50 | 129 | 3.30 | 302 | 4.10 | 566 | 4.90 | 886 | 5.70 | 1,227 |
| 2.60 | 145 | 3.40 | 331 | 4.20 | 602 | 5.00 | 928 | 5.80 | 1,271 |
| 2.70 | 163 | 3.50 | 362 | 4.30 | 640 | 5.10 | 970 | 5.90 | 1,315 |
| 2.80 | 183 | 3.60 | 395 | 4.40 | 680 | 5.20 | 1,012 | 6.00 | 1,360 |
| 2.90 | 205 | 3.70 | 429 | 4.50 | 720 | 5.30 | 1,054 | 6.20 | 1,450 |
| 3.00 | 227 | 3.80 | 463 | 4.60 | 760 | 5.40 | 1,097 | | |
| 3.10 | 250 | 3.90 | 497 | 4.70 | 802 | 5.50 | 1,140 | | |
| 3.20 | 275 | 4.00 | 531 | 4.80 | 844 | 5.60 | 1,183 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904–1906 and is well defined.

*Monthly discharge of Big Lost River near Mackay, Idaho, for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 163 | 154 | 163 | 10,000 |
| February | 154 | 154 | 154 | 8,550 |
| March | 154 | 145 | 148 | 9,100 |
| April | 163 | 154 | 156 | 9,280 |
| May | 802 | 154 | 507 | 31,200 |
| June | 1,450 | 531 | 914 | 54,400 |
| July | 1,200 | 362 | 814 | 50,000 |
| August | 362 | 216 | 270 | 16,600 |
| The period | ..... | ..... | ..... | 189,000 |

NOTE.—Values are rated as excellent. Flow assumed unaffected by ice conditions.

## BIG LOST RIVER NEAR CHILLY, IDAHO.

This station was established April 25, 1904, and was discontinued August 31, 1906. It was located at Howell's ranch, the last one on the left bank, about 25 miles upstream from Mackay, 7 miles from Chilly, and about 3 miles above Kinickinick Point.

The gage is a vertical staff on the left bank one-half mile above the cable, 300 feet from Mr. Howell's house. Until April 20, 1906, the gage was located one-quarter mile from the house. It was moved in order to place it on the main channel. During 1906 it was read once each day by Miss Maud Howell. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 110, where are given also references to publications that contain data for previous years.

*Discharge measurements of Big Lost River near Chilly, Idaho, in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 21 | E. C. La Rue | 81 | 149 | 2.50 | 233 |
| April 22 | do | 81 | 163 | 2.67 | 300 |
| May 8 | do | 84 | 216 | 3.35 | 740 |
| May 9 | do | 85 | 239 | 3.60 | 909 |
| May 24 | do | 83 | 213 | 3.28 | 651 |
| June 14 | do | 92 | 308 | 4.30 | 1,790 |
| August 7 | do | 81.5 | 166 | 2.68 | 310 |
| August 8 | do | 81.5 | 163 | 2.70 | 318 |

*Daily gage height, in feet, of Big Lost River near Chilly, Idaho, for 1906.*

| Day. | Apr. | May. | June. | July. | Aug. | Day. | Apr. | May. | June. | July. | Aug. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 2.75 | 3.2 | 3.6 | 2.8 | 17 | | 3.35 | 4.1 | 3.6 | 2.5 |
| 2 | | 2.9 | 3.1 | 3.8 | 2.8 | 18 | | 3.3 | 3.85 | 3.5 | 2.5 |
| 3 | | 3.1 | 3.2 | 3.9 | 2.75 | 19 | | 3.2 | 3.75 | 3.3 | 2.6 |
| 4 | | 3.35 | 3.4 | 4.0 | 2.7 | 20 | (a) | 3.4 | 3.7 | 3.25 | 2.6 |
| 5 | | 3.3 | 3.5 | 3.95 | 2.7 | 21 | 2.5 | 3.4 | 3.85 | 3.25 | 2.7 |
| 6 | | 3.3 | 3.5 | 3.9 | 2.7 | 22 | 2.65 | 3.3 | 3.9 | 3.25 | 2.7 |
| 7 | | 3.3 | 3.3 | 4.0 | 2.7 | 23 | 2.9 | 3.3 | 3.65 | 3.2 | 2.75 |
| 8 | | 3.4 | 3.25 | 3.85 | 2.7 | 24 | 2.8 | 3.3 | 3.5 | 3.35 | 2.7 |
| 9 | | 3.6 | 3.3 | 3.8 | 2.65 | 25 | 2.7 | 3.4 | 3.6 | 3.05 | 2.6 |
| 10 | | 3.8 | 3.5 | 3.7 | 2.6 | 26 | 2.65 | 3.6 | 3.8 | 3.2 | 2.55 |
| 11 | | 3.8 | 3.9 | 3.75 | 2.6 | 27 | 2.65 | 3.5 | 3.8 | 2.95 | 2.5 |
| 12 | | 3.9 | 4.55 | 3.8 | 2.6 | 28 | 2.6 | 3.4 | 3.9 | 2.9 | 2.5 |
| 13 | | 3.8 | 4.7 | 4.0 | 2.7 | 29 | 2.7 | 3.3 | 3.6 | 2.85 | 2.5 |
| 14 | | 3.85 | 4.3 | 3.9 | 2.6 | 30 | 2.75 | 3.2 | 3.45 | 2.85 | 2.5 |
| 15 | | 3.75 | 4.15 | 3.7 | 2.6 | 31 | | 3.2 | | 2.9 | 2.5 |
| 16 | | 3.5 | 4.4 | 3.5 | 2.5 | | | | | | |

(a) Frozen over January 1 to April 20.

*Rating table for Big Lost River near Chilly, Idaho, for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.10 | 90 | 2.70 | 320 | 3.30 | 660 | 3.90 | 1,260 | 4.50 | 2,080 |
| 2.20 | 120 | 2.80 | 370 | 3.40 | 740 | 4.00 | 1,380 | 4.60 | 2,230 |
| 2.30 | 155 | 2.90 | 420 | 3.50 | 820 | 4.10 | 1,510 | 4.70 | 2,380 |
| 2.40 | 195 | 3.00 | 475 | 3.60 | 910 | 4.20 | 1,650 | | |
| 2.50 | 235 | 3.10 | 530 | 3.70 | 1,020 | 4.30 | 1,790 | | |
| 2.60 | 275 | 3.20 | 590 | 3.80 | 1,140 | 4.40 | 1,930 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 8 discharge measurements made during 1906 and is well defined.

*Monthly discharge of Big Lost River near Chilly, Idaho, for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| April 21–30 | 420 | 235 | 318 | 6,310 |
| May | 1,260 | 345 | 770 | 47,300 |
| June | 2,380 | 530 | 1,100 | 65,800 |
| July | 1,380 | 395 | 885 | 54,400 |
| August | 370 | 235 | 288 | 17,700 |
| The period | | | | 192,000 |

NOTE.—Values are rated as excellent.

## BIG WOOD RIVER NEAR SHOSHONE, IDAHO.

This station was established June 5, 1905, and was discontinued December 31, 1906. It was located at A. D. Silva's ranch, 1 mile below the steel wagon bridge and 7 miles northwest of Shoshone, Idaho. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 113, where are given also references to publications that contain data for previous years.

*Discharge measurements of Big Wood River near Shoshone, Idaho, in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| July 17 | E. C. La Rue | 86 | 112 | 2.50 | 63 |
| 1906. | | | | | |
| April 9 | do | 91 | 297 | 4.76 | 767 |
| April 13 | do | 94 | 469 | 6.50 | 1,810 |
| April 25 | do | 92 | 427 | 6.02 | 1,510 |
| May 5 | do | 92 | 350 | 5.25 | 1,060 |
| May 18 | do | 89 | 287 | 4.63 | 699 |
| June 8 | do | 89 | 262 | 4.31 | 552 |
| July 6 | do | 88 | 249 | 4.18 | 502 |
| July 13 | do | 88 | 223 | 3.87 | 404 |
| July 26 | do | 86 | 122 | 2.70 | 91 |

*Daily gage height, in feet, of Big Wood River near Shoshone, Idaho, for 1906.*

| Day. | Mar. | Apr. | May. | June. | July. | Aug. | Day. | Mar. | Apr. | May. | June. | July. | Aug. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 3.3 | 5.05 | 4.3 | 3.9 | 1.95 | 17 | | 7.45 | 4.95 | 5.05 | 3.6 | |
| 2 | | 2.5 | 5.1 | 4.15 | 3.8 | 1.75 | 18 | | 7.1 | 4.7 | 4.85 | 3.4 | |
| 3 | | 2.3 | 5.0 | 4.0 | 4.0 | | 19 | | 6.9 | 4.5 | 4.65 | 3.4 | |
| 4 | | 2.2 | 5.1 | 4.0 | 4.1 | | 20 | | 6.0 | 4.3 | 4.55 | 3.2 | |
| 5 | | 2.2 | 5.25 | 4.1 | 4.2 | | 21 | | 5.8 | 4.25 | 4.4 | 3.1 | |
| 6 | | 2.3 | 5.25 | 4.4 | 4.2 | | 22 | | 5.8 | 4.15 | 4.3 | 2.9 | |
| 7 | | 3.2 | 5.15 | 4.45 | 4.15 | | 23 | | 6.0 | 4.0 | 4.4 | 2.8 | |
| 8 | | 4.0 | 5.0 | 4.35 | 4.2 | | 24 | | 6.2 | 3.9 | 4.2 | 3.0 | |
| 9 | | 4.6 | 5.0 | 4.2 | 4.2 | | 25 | | 6.1 | 3.8 | 4.05 | 2.8 | |
| 10 | | 5.4 | 5.0 | 4.0 | 4.25 | | 26 | 2.2 | 5.9 | 3.75 | 3.75 | 2.75 | |
| 11 | | 5.7 | 5.05 | 4.0 | 4.05 | | 27 | 2.35 | 5.7 | 4.05 | 4.1 | 2.6 | |
| 12 | | 6.4 | 5.05 | 4.1 | 4.0 | | 28 | 2.35 | 5.4 | 4.3 | 4.2 | 2.4 | |
| 13 | | 6.4 | 5.1 | 4.9 | 3.9 | | 29 | 3.1 | 5.15 | 4.5 | 4.4 | 2.35 | |
| 14 | | 6.9 | 5.1 | 5.35 | 3.9 | | 30 | 3.4 | 5.1 | 4.5 | 4.15 | 2.2 | |
| 15 | | 8.0 | 5.2 | 5.1 | 4.0 | | 31 | 3.3 | | 4.4 | | 2.0 | |
| 16 | | 7.9 | 5.2 | 4.95 | 3.8 | | | | | | | | |

NOTE.—The river was dry January 1 to March 25 and August 2 to December 31.

*Rating table for Big Wood River near Shoshone, Idaho, for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.90 | 0 | 2.90 | 124 | 3.90 | 410 | 4.90 | 845 | 6.60 | 1,870 |
| 2.00 | 9 | 3.00 | 145 | 4.00 | 445 | 5.00 | 900 | 6.80 | 2,010 |
| 2.10 | 19 | 3.10 | 170 | 4.10 | 480 | 5.20 | 1,010 | 7.00 | 2,150 |
| 2.20 | 29 | 3.20 | 195 | 4.20 | 515 | 5.40 | 1,130 | 7.20 | 2,300 |
| 2.30 | 40 | 3.30 | 220 | 4.30 | 550 | 5.60 | 1,230 | 7.40 | 2,450 |
| 2.40 | 51 | 3.40 | 250 | 4.40 | 590 | 5.80 | 1,370 | 7.60 | 2,610 |
| 2.50 | 63 | 3.50 | 280 | 4.50 | 635 | 6.00 | 1,490 | 7.80 | 2,780 |
| 2.60 | 76 | 3.60 | 310 | 4.60 | 685 | 6.20 | 1,610 | 8.00 | 2,950 |
| 2.70 | 90 | 3.70 | 340 | 4.70 | 735 | 6.40 | 1,740 | | |
| 2.80 | 106 | 3.80 | 375 | 4.80 | 790 | | | | |

NOTE.—The above table is applicable for open-channel conditions. It is based on 10 discharge measurements made during 1905-6 and is well defined.

*Monthly discharge of Big Wood River near Shoshone, Idaho, for 1905–6.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| 1905.[a] | | | | |
| June 5–30 | 410 | 115 | 260 | 13,400 |
| July | 115 | 0 | 58 | 3,570 |
| The period | | | | 17,000 |
| 1906.[b] | | | | |
| January | | | 0 | 0 |
| February | | | 0 | 0 |
| March | 250 | 0 | 24 | 1,480 |
| April | 2,950 | 29 | 1,240 | 73,500 |
| May | 1,040 | 357 | 760 | 46,700 |
| June | 1,100 | 357 | 604 | 35,900 |
| July | 532 | 9 | 300 | 18,400 |
| August | 4 | 0 | .13 | 8 |
| September | | | 0 | 0 |
| October | | | 0 | 0 |
| November | | | 0 | 0 |
| December | | | 0 | 0 |
| The year | | | | 176,000 |

[a] Values for 1905 are rated as good.
[b] Values for 1906 are rated as follows: March and August, approximate; April to June, excellent; July, good.

NOTE.—River dry July 28 to December 31, 1905.

## SUCCOR CREEK NEAR HOMEDALE, IDAHO.

This station was established March 19, 1903. It was originally located at a small truss bridge built to carry a flume, about one-half mile above the mouth of the river. The station was moved January 31, 1905, about one-half mile upstream to a location 1 mile west of Homedale and about 17 miles from Caldwell, the nearest railroad station. It is near the Caldwell-Jordan Valley stage road, 1 mile west of Mussel's ferry on Snake River, one-fourth mile below the head of the lowest ditch on Succor Creek, and about three-fourths mile above the mouth of the creek. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 114, where are given also references to publications that contain data for previous years.

*Discharge measurements of Succor Creek near Homedale, Idaho, in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 9 | E. C. La Rue | 35 | 46 | 3.58 | 126 |
| March 10 | do | 40 | 58 | 3.90 | 216 |
| April 3 | do | 45 | 71 | 4.35 | 370 |
| June 7 | do | 36 | 47 | 3.50 | 125 |
| July 3 | do | ..... | .30 | 2.10 | .2 |

*Daily gage height, in feet, of Succor Creek near Homedale, Idaho, for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | Dec. |
|---|---|---|---|---|---|---|---|
| 1 | 1.95 | 2.6 | 3.25 | 4.6 | 3.3 | 3.95 | ..... |
| 2 | 1.95 | 2.55 | 3.05 | 4.6 | 3.3 | 3.9 | ..... |
| 3 | 1.95 | 2.55 | 3.05 | 4.2 | 3.25 | 3.6 | ..... |
| 4 | 1.95 | 2.6 | 3.6 | 3.9 | 3.2 | 3.6 | ..... |
| 5 | 1.95 | 2.65 | 3.25 | 4.0 | 3.2 | 3.75 | 2.0 |
| 6 | 1.95 | 2.65 | 3.25 | 4.3 | 3.1 | 3.6 | 2.1 |
| 7 | 1.95 | 2.6 | 3.25 | 4.2 | 2.95 | 3.5 | 2.25 |
| 8 | 1.95 | 2.6 | 3.3 | 4.4 | 2.9 | 3.5 | 2.3 |
| 9 | 1.95 | 2.55 | 3.5 | 4.5 | 2.9 | 3.45 | 2.3 |
| 10 | 1.95 | 2.5 | 3.8 | 4.3 | 2.85 | 3.4 | 2.3 |
| 11 | 2.0 | 2.6 | 3.4 | 3.8 | 2.8 | 3.2 | 2.3 |
| 12 | 2.0 | 2.55 | 3.1 | 3.5 | 3.2 | 3.1 | 2.3 |
| 13 | 2.3 | 2.55 | 3.1 | 3.4 | 3.05 | 3.0 | 2.3 |
| 14 | 2.2 | 2.6 | 3.1 | 3.5 | 2.95 | 2.95 | 2.3 |
| 15 | 2.3 | 2.8 | 3.1 | 3.6 | 3.0 | 2.9 | 2.3 |
| 16 | 2.3 | 3.45 | 2.75 | 3.8 | 2.9 | 3.0 | 2.3 |
| 17 | 2.3 | 3.5 | 2.7 | 3.8 | 2.8 | 2.9 | 2.3 |
| 18 | 2.4 | 3.4 | 2.8 | 3.7 | 2.75 | 2.8 | 2.3 |
| 19 | 3.75 | 4.2 | 2.8 | 3.7 | 2.7 | 2.7 | 2.3 |
| 20 | 2.5 | 3.25 | 2.95 | 3.6 | 2.65 | 2.6 | 2.35 |
| 21 | 2.5 | 3.4 | 3.0 | 3.8 | 2.65 | 2.45 | 2.3 |
| 22 | 2.5 | 3.25 | 3.95 | 3.8 | 2.65 | 2.45 | 2.3 |
| 23 | 2.65 | 3.0 | 4.0 | 3.7 | 2.55 | 2.45 | 2.3 |
| 24 | 3.25 | 3.0 | 4.6 | 3.7 | 2.5 | 2.2 | 2.35 |
| 25 | 3.3 | 3.05 | 4.75 | 3.7 | 2.45 | 2.15 | 2.4 |
| 26 | 3.3 | 2.95 | 4.2 | 3.5 | 2.4 | 2.1 | 2.35 |
| 27 | 2.9 | 3.3 | 4.3 | 3.45 | 2.3 | 2.45 | 2.3 |
| 28 | 2.8 | 4.15 | 4.0 | 3.35 | 2.7 | 2.25 | 2.45 |
| 29 | 2.7 | ..... | 3.9 | 3.3 | 4.75 | 2.1 | 2.5 |
| 30 | 2.6 | ..... | 4.2 | 3.3 | 4.2 | 2.0 | 2.45 |
| 31 | 2.65 | ..... | 4.7 | ..... | 4.0 | ..... | 2.5 |

NOTE.—Creek dry June 30 to December 4, 1906.

*Rating table for Succor Creek near Homedale, Idaho, for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.00 | 0.0 | 2.60 | 18 | 3.20 | 71 | 3.80 | 184 | 4.40 | 389 |
| 2.10 | .2 | 2.70 | 24 | 3.30 | 83 | 3.90 | 214 | 4.50 | 426 |
| 2.20 | 3 | 2.80 | 31 | 3.40 | 97 | 4.00 | 247 | 4.60 | 464 |
| 2.30 | 6 | 2.90 | 40 | 3.50 | 114 | 4.10 | 281 | 4.70 | 502 |
| 2.40 | 9 | 3.00 | 50 | 3.60 | 134 | 4.20 | 316 | 4.80 | 542 |
| 2.50 | 13 | 3.10 | 60 | 3.70 | 157 | 4.30 | 352 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 5 discharge measurements made during 1906, and is not well defined below 3.5 feet.

*Monthly discharge of Succor Creek near Homedale, Idaho, for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 170 | 0 | 20.7 | 1,270 |
| February | 316 | 13 | 61.9 | 3,440 |
| March | 522 | 24 | 158 | 9,720 |
| April | 464 | 83 | 210 | 12,500 |
| May | 522 | 6 | 71.2 | 4,380 |
| June | 230 | 0 | 64.3 | 3,830 |
| July | 0 | 0 | 0 | 0 |
| August | 0 | 0 | 0 | 0 |
| September | 0 | 0 | 0 | 0 |
| October | 0 | 0 | 0 | 0 |
| November | 0 | 0 | 0 | 0 |
| December | 13 | 0 | 5.8 | 357 |
| The year | | | | 35,500 |

NOTE.—Values are rated as follows: January, February, May, June, and December, approximate; March and April, good. Flow assumed unaffected by ice during winter period.

## OWYHEE RIVER NEAR OWYHEE, OREG.

This station was established August 27, 1903, at the county bridge 1½ miles from Owyhee, Oreg. Owyhee ditch takes water from the river about 6 miles above. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 116, where are given also references to publications that contain data for previous years.

*Discharge measurements of Owyhee River near Owyhee, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 8 | R. S. Hall | 273 | 556 | 3.58 | 760 |
| March 31 | do | 290 | 1,870 | 8.32 | 9,620 |
| April 13 | do | 286 | 1,720 | 7.61 | 7,780 |
| April 27 | do | 286 | 1,470 | 6.72 | 5,440 |
| June 13 | do | 282 | 940 | 5.02 | 2,290 |
| November 29[a] | Stevens and McGlashan | 120 | 192 | 2.80 | 231 |

[a] Slush ice running. Right channel entirely frozen.

*Daily gage height, in feet, of Owyhee River near Owyhee, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.97 | 3.42 | 3.42 | 9.00 | 5.90 | 7.12 | 3.97 | 2.02 | 2.02 | 2.37 | 2.32 | 2.75 |
| 2 | 2.97 | 3.37 | 3.42 | 8.97 | 5.87 | 7.10 | 3.87 | 2.04 | 2.02 | 2.37 | 2.32 | 2.75 |
| 3 | 2.97 | 3.32 | 3.42 | 7.78 | 5.82 | 6.52 | 3.72 | 2.00 | 2.02 | 2.37 | 2.32 | 2.75 |
| 4 | 2.97 | 3.37 | 3.42 | 7.24 | 5.79 | 6.42 | 3.62 | 1.97 | 2.02 | 2.37 | 2.32 | 2.75 |
| 5 | 2.97 | 3.37 | 3.42 | 7.04 | 5.77 | 6.27 | 3.67 | 1.92 | 2.02 | 2.37 | 2.32 | 2.75 |
| 6 | 3.02 | 3.37 | 3.42 | 7.02 | 5.72 | 6.02 | 3.47 | 1.92 | 2.02 | 2.37 | 2.32 | 2.75 |
| 7 | 3.02 | 3.37 | 3.42 | 7.14 | 5.67 | 5.87 | 3.32 | 1.92 | 2.02 | 2.42 | 2.34 | 2.75 |
| 8 | 3.02 | 3.37 | 3.57 | 8.12 | 5.57 | 5.74 | 3.22 | 1.92 | 2.02 | 2.37 | 2.37 | 2.75 |
| 9 | 3.02 | 3.37 | 3.90 | 8.87 | 5.47 | 5.52 | 3.22 | 1.92 | 2.02 | 2.37 | 2.40 | 2.75 |
| 10 | 3.02 | 3.37 | 4.02 | 9.00 | 5.37 | 5.67 | 3.42 | 1.92 | 2.02 | 2.37 | 2.42 | 2.75 |
| 11 | 3.02 | 3.27 | 4.10 | 8.60 | 5.27 | 5.57 | 2.97 | 1.92 | 2.02 | 2.30 | 2.45 | 2.75 |
| 12 | 3.22 | 3.32 | 4.12 | 8.22 | 5.37 | 5.47 | 2.97 | 1.92 | 2.02 | 2.30 | 2.47 | 2.75 |
| 13 | 3.22 | 3.27 | 4.12 | 7.72 | 5.27 | 5.37 | 2.92 | 1.92 | 2.04 | 2.30 | 2.52 | 2.75 |
| 14 | 3.22 | 3.22 | 4.12 | 7.32 | 5.22 | 5.27 | 2.92 | 1.92 | 2.04 | 2.30 | 2.57 | 2.75 |
| 15 | 3.22 | 3.22 | 4.12 | 7.32 | 5.17 | 5.07 | 2.90 | 1.92 | 2.02 | 2.30 | 2.60 | 2.75 |

*Daily gage height, in feet, of Owyhee River near Owyhee, Oreg., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 3.22 | 3.22 | 4.17 | 7.42 | 5.12 | 4.92 | 2.87 | 1.92 | 2.02 | 2.30 | 2.64 | 2.75 |
| 17 | 3.22 | 3.17 | 4.07 | 7.57 | 5.07 | 4.77 | 2.87 | 1.92 | 2.07 | 2.30 | 2.70 | 2.75 |
| 18 | 3.22 | 2.92 | 3.87 | 7.42 | 5.02 | 4.57 | 2.82 | 1.97 | 2.14 | 2.30 | 2.72 | 2.75 |
| 19 | 3.60 | 3.00 | 3.70 | 7.32 | 4.97 | 4.47 | 2.82 | 1.97 | 2.14 | 2.30 | 2.72 | 2.75 |
| 20 | 3.90 | 3.07 | 3.57 | 7.27 | 4.92 | 4.47 | 2.82 | 1.97 | 2.14 | 2.32 | 2.72 | 2.75 |
| 21 | 3.42 | 3.06 | 3.47 | 6.87 | 4.82 | 4.39 | 2.80 | 1.97 | 2.14 | 2.32 | 2.72 | 2.75 |
| 22 | 3.42 | 3.17 | 3.47 | 6.82 | 4.67 | 4.32 | 2.72 | 1.97 | 2.14 | 2.32 | 2.72 | 2.75 |
| 23 | 3.42 | 3.32 | 5.70 | 6.72 | 4.57 | 4.17 | 2.62 | 1.97 | 2.14 | 2.32 | 2.72 | 2.75 |
| 24 | 3.42 | 3.37 | 5.44 | 6.52 | 4.42 | 4.11 | 2.57 | 1.97 | 2.14 | 2.32 | 2.72 | 2.76 |
| 25 | 3.47 | 3.52 | 6.61 | 6.62 | 4.27 | 4.02 | 2.47 | 2.02 | 2.14 | 2.32 | 2.72 | 2.75 |
| 26 | 3.47 | 3.42 | 7.62 | 6.52 | 4.22 | 3.97 | 2.32 | 2.02 | 2.14 | 2.32 | 2.72 | 2.75 |
| 27 | 3.47 | 3.37 | 8.04 | 6.47 | 4.14 | 3.92 | 2.27 | 2.02 | 2.37 | 2.32 | 2.67 | 2.75 |
| 28 | 3.47 | 3.37 | 7.94 | 6.42 | 4.12 | 3.87 | 2.22 | 2.02 | 2.37 | 2.32 | 2.67 | 2.80 |
| 29 | 3.47 | ..... | 8.02 | 6.32 | 4.62 | 3.90 | 2.17 | 2.02 | 2.37 | 2.32 | 2.75 | 2.85 |
| 30 | 3.47 | ..... | 7.87 | 6.12 | 6.62 | 3.97 | *2.12 | 2.02 | 2.37 | 2.32 | 2.75 | 2.85 |
| 31 | 3.47 | ..... | 8.52 | ..... | 7.07 | ..... | 2.07 | 2.02 | ..... | 2.32 | ..... | 2.90 |

NOTE.—There was probably some obstruction from ice during the latter part of November and December. No correction has been made in discharge.

*Rating table for Owyhee River near Owyhee, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.90 | 15 | 2.90 | 295 | 3.90 | 995 | 4.90 | 2,100 | 6.80 | 5,680 |
| 2.00 | 25 | 3.00 | 350 | 4.00 | 1,080 | 5.00 | 2,240 | 7.00 | 6,160 |
| 2.10 | 35 | 3.10 | 410 | 4.10 | 1,170 | 5.20 | 2,540 | 7.20 | 6,660 |
| 2.20 | 50 | 3.20 | 475 | 4.20 | 1,270 | 5.40 | 2,860 | 7.40 | 7,180 |
| 2.30 | 70 | 3.30 | 540 | 4.30 | 1,370 | 5.60 | 3,210 | 7.60 | 7,700 |
| 2.40 | 95 | 3.40 | 610 | 4.40 | 1,480 | 5.80 | 3,580 | 7.80 | 8,240 |
| 2.50 | 125 | 3.50 | 680 | 4.50 | 1,590 | 6.00 | 3,960 | 8.00 | 8,780 |
| 2.60 | 160 | 3.60 | 755 | 4.60 | 1,710 | 6.20 | 4,360 | 9.00 | 11,570 |
| 2.70 | 200 | 3.70 | 830 | 4.70 | 1,830 | 6.40 | 4,780 | | |
| 2.80 | 245 | 3.80 | 910 | 4.80 | 1,960 | 6.60 | 5,220 | | |

NOTE.—This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is well defined.

*Monthly discharge of Owyhee River near Owyhee, Oreg., for 1906.*

[Drainage area, 9,880 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 995 | 333 | 519 | 31,900 | 0.052 | 0.06 |
| February | 695 | 306 | 533 | 29,600 | .054 | .06 |
| March | 10,200 | 624 | 2,700 | 166,000 | .272 | .31 |
| April | 11,600 | 4,200 | 7,250 | 432,000 | .733 | .82 |
| May | 6,340 | 1,190 | 2,700 | 166,000 | .270 | .31 |
| June | 6,460 | 970 | 2,640 | 157,000 | .267 | .30 |
| July | 1,060 | 32 | 367 | 22,600 | .037 | .04 |
| August | 29 | 17 | 21.5 | 1,320 | .0022 | .002 |
| September | 88 | 27 | 39.6 | 2,360 | .0040 | .004 |
| October | 102 | 70 | 78.2 | 4,810 | .0079 | .01 |
| November | 222 | 75 | 152 | 9,040 | .015 | .02 |
| December | 295 | 222 | 228 | 14,000 | 023 | .03 |
| The year | 11,600 | 17 | 1,210 | 1,040,000 | .122 | 1.97 |

NOTE.—Values are rated as good.

## BOISE RIVER NEAR HIGHLAND, IDAHO.

This station was established on July 27, 1905, to replace the Boise station. It is located 2 miles below the mouth of Moores Creek, 3 miles southwest of Highland post-office, about 8 miles above the old Boise station, and 15 miles east of Boise, the nearest railroad point. The conditions and the bench marks are described in Water-Supply Paper No. 178, page 121.

*Discharge measurements of Boise River near Highland, Idaho, in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 3 | E. C. La Rue | 180 | 309 | 3.85 | 1,130 |
| April 4 | do | 220 | 831 | 6.38 | 3,150 |
| April 15 | do | 233 | 1,260 | 8.20 | 5,630 |
| May 16 | do | 235 | 1,520 | 9.40 | 7,260 |
| June 6 | do | 230 | 1,340 | 8.80 | 6,590 |
| June 29 | do | 226 | 1,160 | 7.90 | 5,040 |
| July 11 | do | 220 | 844 | 6.55 | 3,090 |
| July 16 | do | 216 | 669 | 5.75 | 2,350 |
| July 20 | do | 202 | 550 | 5.10 | 1,750 |
| July 24 | do | 193 | 442 | 4.60 | 1,480 |
| July 27 | do | 188 | 368 | 4.20 | 1,310 |

*Daily gage height, in feet, of Boise River near Highland, Idaho, for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.3 | 3.5 | 4.0 | 7.55 | 9.1 | 8.35 | 7.25 | 3.9 | 3.4 | 3.15 | 3.4 |
| 2 | 3.3 | 3.45 | 3.85 | 6.9 | 9.2 | 8.2 | 7.35 | 3.85 | 3.4 | 3.1 | 3.4 |
| 3 | 3.25 | 3.45 | 3.85 | 6.55 | 9.5 | 8.3 | 7.5 | 3.8 | 3.45 | 3.15 | 3.4 |
| 4 | 3.3 | 3.5 | 3.85 | 6.4 | 9.9 | 8.6 | 7.55 | 3.8 | 3.35 | 3.25 | 3.4 |
| 5 | 3.4 | 3.4 | 3.85 | 6.25 | 9.5 | 8.65 | 7.4 | 3.7 | 3.3 | 3.35 | 3.45 |
| 6 | 3.6 | 3.45 | 3.8 | 6.8 | 9.35 | 8.85 | 7.3 | 3.65 | 3.3 | 3.35 | 3.45 |
| 7 | 3.4 | 3.45 | 3.8 | 7.4 | 9.25 | 8.35 | 7.2 | 3.65 | 3.25 | 3.3 | 3.5 |
| 8 | 3.4 | 3.5 | 4.0 | 7.95 | 9.45 | 8.35 | 7.05 | 3.6 | 3.25 | 3.2 | 3.5 |
| 9 | 3.4 | 3.5 | 4.4 | 8.05 | 9.55 | 8.2 | 6.9 | 3.55 | 3.25 | 3.2 | 3.55 |
| 10 | 3.5 | 3.5 | 4.6 | 8.3 | 9.95 | 8.25 | 6.7 | 3.5 | 3.25 | 3.15 | 3.6 |
| 11 | 3.6 | 3.5 | 4.5 | 7.75 | 10.05 | 8.5 | 6.55 | 3.45 | 3.25 | 3.15 | 3.6 |
| 12 | 3.6 | 3.6 | 4.4 | 7.6 | 10.3 | 9.5 | 6.5 | 3.4 | 3.25 | 3.2 | 3.5 |
| 13 | 3.5 | 3.65 | 4.3 | 7.7 | 10.3 | 9.85 | 6.3 | 3.5 | 3.45 | 3.3 | 3.8 |
| 14 | 3.5 | 3.7 | 4.1 | 7.75 | 10.15 | 9.15 | 6.15 | 3.55 | 3.5 | 3.25 | 5.75 |
| 15 | 3.5 | 3.75 | 3.9 | 8.2 | 10.1 | 9.05 | 5.9 | 3.5 | 3.4 | 3.15 | 6.0 |
| 16 | 3.5 | 3.9 | 3.6 | 8.6 | 9.5 | 8.95 | 5.75 | 3.4 | 3.35 | 3.25 | 8.05 |
| 17 | 3.5 | 4.0 | 3.4 | 8.75 | 8.85 | 8.95 | 5.6 | 3.4 | 3.3 | 3.3 | 5.5 |
| 18 | 3.8 | 4.1 | 3.5 | 8.8 | 8.5 | 8.55 | 5.45 | 3.35 | 3.3 | 3.35 | 4.6 |
| 19 | 3.7 | 4.25 | 3.6 | 8.85 | 8.35 | 8.3 | 5.3 | 3.25 | 3.25 | 3.3 | 3.95 |
| 20 | 3.6 | 4.2 | 3.8 | 8.9 | 8.35 | 8.15 | 5.1 | 3.3 | 3.25 | 3.3 | 3.9 |
| 21 | 3.5 | 4.1 | 3.9 | 9.5 | 8.35 | 8.1 | 4.95 | 3.3 | 3.2 | 3.3 | 4.0 |
| 22 | 3.7 | 4.2 | 4.0 | 9.9 | 8.25 | 8.0 | 4.85 | 3.4 | 3.15 | 3.3 | 4.0 |
| 23 | 3.6 | 4.1 | 4.3 | 10.2 | 8.1 | 7.9 | 4.95 | 3.55 | 3.15 | 3.3 | 3.8 |
| 24 | 3.5 | 3.95 | 4.65 | 9.75 | 8.15 | 7.7 | 4.6 | 3.65 | 3.15 | 3.3 | 3.7 |
| 25 | 3.5 | 3.9 | 5.65 | 9.5 | 8.2 | 7.7 | 4.45 | 3.6 | 3.15 | 3.3 | 3.7 |
| 26 | 3.7 | 3.9 | 6.2 | 8.9 | 9.25 | 7.8 | 4.35 | 3.45 | 3.15 | 3.3 | 3.65 |
| 27 | 3.6 | 3.85 | 6.5 | 8.75 | 9.05 | 7.9 | 4.2 | 3.45 | 3.15 | 3.3 | 3.65 |
| 28 | 3.5 | 4.15 | 6.5 | 8.7 | 8.9 | 8.5 | 4.15 | 3.35 | 3.15 | 3.35 | 3.65 |
| 29 | 3.5 | ..... | 6.65 | 8.9 | 8.85 | 7.9 | 4.05 | 3.45 | 3.15 | 3.35 | 3.55 |
| 30 | 3.4 | ..... | 6.75 | 8.95 | 8.6 | 7.5 | 4.0 | 3.45 | 3.15 | 3.35 | 3.5 |
| 31 | 3.4 | ..... | 7.25 | ..... | 8.5 | ..... | 3.95 | 3.4 | ..... | 3.35 | ..... |

NOTE.—Record discontinued for the winter on December 1.

*Rating table for Boise River near Highland, Idaho, for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.00 | 560 | 4.00 | 1,240 | 5.00 | 1,700 | 6.00 | 2,620 | 8.00 | 5,180 |
| 3.10 | 600 | 4.10 | 1,280 | 5.10 | 1,780 | 6.20 | 2,840 | 8.20 | 5,470 |
| 3.20 | 650 | 4.20 | 1,310 | 5.20 | 1,860 | 6.40 | 3,060 | 8.40 | 5,770 |
| 3.30 | 700 | 4.30 | 1,350 | 5.30 | 1,940 | 6.60 | 3,300 | 8.60 | 6,070 |
| 3.40 | 750 | 4.40 | 1,390 | 5.40 | 2,020 | 6.80 | 3,540 | 8.80 | 6,370 |
| 3.50 | 810 | 4.50 | 1,430 | 5.50 | 2,110 | 7.00 | 3,800 | 9.00 | 6,670 |
| 3.60 | 880 | 4.60 | 1,470 | 5.60 | 2,200 | 7.20 | 4,060 | 10.00 | 8,240 |
| 3.70 | 960 | 4.70 | 1,510 | 5.70 | 2,300 | 7.40 | 4,340 | | |
| 3.80 | 1,060 | 4.80 | 1,560 | 5.80 | 2,400 | 7.60 | 4,620 | | |
| 3.90 | 1,160 | 4.90 | 1,620 | 5.90 | 2,510 | 7.80 | 4,900 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 15 discharge measurements made during 1905–6, and is well defined between gage heights 3 feet and 9 feet.

*Monthly discharge of Boise River near Highland, Idaho, for 1906.*

[Drainage area, 2,610 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec-ft. per sq. mile. | Depth in inches. |
| January | 1,060 | 675 | 820 | 50,400 | 0.314 | 0.36 |
| February | 1,350 | 750 | 1,020 | 56,800 | .391 | .41 |
| March | 4,130 | 750 | 1,630 | 100,000 | .624 | .72 |
| April | 8,560 | 2,900 | 5,650 | 335,000 | 2.15 | 2.40 |
| May | 8,720 | 5,320 | 6,900 | 425,000 | 2.64 | 3.04 |
| June | 8,000 | 4,480 | 8,780 | 344,000 | 2.21 | 2.47 |
| July | 4,550 | 1,200 | 2,630 | 162,000 | 1.00 | 1.15 |
| August | 1,160 | 675 | 839 | 51,600 | .321 | .37 |
| September | 810 | 625 | 685 | 40,800 | .262 | .29 |
| October | 725 | 600 | 683 | 42,000 | .261 | .30 |
| November | 5,250 | 750 | 1,220 | 72,800 | .468 | .52 |
| The period | | | | 1,680,000 | | |

NOTE.—Values are rated as excellent. Flow assumed unaffected by ice conditions during the winter months

## SEEPAGE INVESTIGATIONS ON BOISE RIVER.

The following is a detailed report of the investigation made by E. C. La Rue during October, 1906, in order to determine the amount of seepage water returning to Boise River between the mouth of its canyon, 8 miles above Boise, and Caldwell Canyon, $2\frac{1}{2}$ miles above Caldwell, Idaho.

The distance by river between the points is 34 miles. This distance was covered on foot and by following the river bank, and the discharge of every diversion and tributary was carefully noted.

The gage reading at the Highland station on Boise River, about 8 miles above the mouth of Boise Canyon, was 3.20 on October 9, 1906, which corresponds to a discharge of 650 second-feet. From here to Boise Canyon the river flows through a narrow rocky canyon and receives no tributaries. Consequently 650 second-feet is the discharge at the mouth of the canyon, just above the New York canal heading. On October 12, 1906, the day the investigation was finished, the gage at the Highland station still read 3.20. Therefore during this period

of investigation the uniform available supply of the river above all irrigation was 650 second-feet.

The net seepage will be the difference between the discharge of the river at the upper point, plus all tributaries between the two points of measurement, and the discharge of the river at the lower point, plus all diverted water between the two points in question.

The results are expressed in the following table:

*Discharge of Boise River at upper point, plus tributaries.*

| Date. | Stream. | Locality of heading or place of measurement. | Discharge in second-feet. |
|---|---|---|---|
| 1906. | | | |
| October 9 | Boise River | At mouth of canyon, above New York canal heading. | 650 |
| October 9 | Waste from sloughs | Between Ninth and Broadway Bridge | .5 |
| October 9 | Waste from canals and sloughs. | Between Broadway Bridge and Ridenbaugh canal heading. | 2.8 |
| October 10 | Waste from Rossi canal | ½ mile below Broadway Bridge | 17.8 |
| October 10 | do | Just above Oregon Short Line Railway bridge. | 38.1 |
| October 10 | do | Just below Oregon Short Line Railway bridge. | 98.6 |
| October 10 | Waste | Below Mill slough ditch heading | 13.0 |
| October 10 | do | From Lower Mill slough ditch | 3.0 |
| October 10 | do | Just above Phyllis canal heading | 1.0 |
| October 10 | do | From Eureka canal | 3.0 |
| October 11 | do | 3 miles below Star Bridge | 4.0 |
| October 11 | Willow Creek waste | ½ mile below Middleton | 21.1 |
| October 12 | Waste Middleton Mill slough. | At Middleton | 4.0 |
| October 12 | Waste | Just below Farmers' Union canal heading | 2.0 |
| October 12 | do | Boise City sewer discharge | 10.0 |
| | Total | | 868.9 |

*Discharge of Boise River at lower point, plus all diversions.*

| Date. | Stream. | Locality of heading or place of measurement. | Discharge in second-feet. |
|---|---|---|---|
| 1906. | | | |
| October 9 | New York canal | Below all waste | 95.5 |
| October 9 | Ridenbaugh canal | Just below wasteway | 209.4 |
| October 9 | Rossi canal | Just above wasteway | 205.9 |
| October 9 | Small diversion | ½ mile above Rossi heading | 1.0 |
| October 9 | Payne ditch | At heading | 1.0 |
| October 10 | Davis or Mill slough ditch | Below wasteway | 20.1 |
| October 10 | Joplin ditch | At heading | 4.0 |
| October 10 | Eureka canal | Below wasteway | 9.3 |
| October 10 | Phyllis canal | do | 58.6 |
| October 11 | Boise River | At lower point of measurement, 2½ miles above Caldwell. | 95.1 |
| October 11 | Caldwell Highline canal | Below all waste | 26.7 |
| October 12 | Canyon County canal | Below wasteway | 9.2 |
| October 12 | Small diversion | 3 miles above Star | 1.0 |
| October 12 | Middleton Mill ditch | Below wasteway | 35.0 |
| October 12 | Middleton Mill slough ditch | do | 8.9 |
| October 12 | Pioneer or Stewart ditch | | 0.0 |
| October 12 | Ballantyne ditch | Below all waste | 1.0 |
| October 12 | Dry Creek ditch | Below wasteway | 10.8 |
| October 12 | Farmers' Union and Valley ditch. | do | 61.6 |
| October 12 | Boise City ditch | do | 9.5 |
| October 12 | Perrault ditch | At penitentiary | 9.4 |
| | Total | | 873.0 |

Investigations similar to the foregoing were made during 1898, 1901, 1902, 1903, and 1905. The results of these investigations, including the summary for 1906, are given below:

*Seepage gains in Boise River.*

| | Sec.-ft. | Sec.-ft. |
|---|---|---|
| 1898, August 24 to September 2: | | |
| Amount taken out by canals | | 1,160.0 |
| Amount in river above canals | 734 | |
| Amount of measured return water | 197 | |
| Total | 931 | |
| Amount in river at Caldwell station | 31 | |
| Difference | | 900.0 |
| Gain by seepage in 34 miles | | 260.0 |
| 1901, August 13 to 17: | | |
| Discharge Boise River above New York canal heading | | 821.0 |
| Discharge Boise River at Caldwell Canyon | 73.3 | |
| Amount of measured return water | | 131.0 |
| Amount taken out by canals | 1,140.1 | |
| Gain by seepage in 34 miles | | 261.4 |
| | 1,213.4 | 1,213.4 |
| 1902, August 11 to 15: | | |
| Discharge Boise River at upper point | | 924.5 |
| Discharge Boise River at lower point | 1.5 | |
| Amount of measured return waters | | 174.4 |
| Amount taken out by canals | 1,309.0 | |
| Gain by seepage in 34 miles | | 211.6 |
| | 1,310.5 | 1,310.5 |
| 1903, October 24 to 29: | | |
| Discharge of Boise River at upper point | | 771.6 |
| Discharge of Boise River at lower point | 619.4 | |
| Amount of measured return waters | | 362.6 |
| Amount taken out by canals | 654.4 | |
| Gain by seepage in 34 miles | | [a] 139.6 |
| | 1,273.8 | 1,273.8 |
| 1905, October 2 to 7: | | |
| Discharge Boise River at upper point | | 602.0 |
| Discharge Boise River at lower point | 106.6 | |
| Amount of measured return waters | | 82.7 |
| Amount taken out by canals | 601.5 | |
| Gain by seepage in 34 miles | | 23.4 |
| | 708.1 | 708.1 |

[a] Mistakes were found in calculation. The result of 255.3 second-feet gain, as published in Water-Supply Paper No. 100, should read 139.6 second-feet.

| 1906, October 9 to 12: | Sec.-ft. | Sec.-ft. |
|---|---|---|
| Discharge Boise River at upper point | | 650.0 |
| Discharge Boise River at lower point | 95.1 | |
| Amount of measured return water | | 218.9 |
| Amount taken out by canals | 777.9 | |
| Gain by seepage in 34 miles | | 4.1 |
| | 873.0 | 873.0 |

## PAYETTE RIVER NEAR HORSESHOE BEND, IDAHO.

This station was established February 13, 1906. It is located at a point known as Jerusalem, 5 miles above Horseshoe Bend postoffice, Idaho, and about 32 miles from Boise, the most convenient railway point.

The channel is straight for 1,000 feet above and below the station. The water is comparatively swift during all stages. Both banks are firm, rather steep, and not liable to overflow. The bed of the stream is strewn with small smooth bowlders, and is permanent.

Discharge measurements are made by means of a cable and car. The initial point for soundings is the inner face of the pine tree which acts as the right cable support.

The gage, which was read once each day by E. R. Sherard, is inclined and is located on the right bank directly under the cable. The bench mark is a United States Geological Survey aluminum tablet set in the base of the pine tree which is used as the cable support on the right bank; elevation, 12.53 feet above the datum of the gage.

*Discharge measurements of Payette River near Horseshoe Bend, Idaho, by E. C. La Rue, in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 24 | 253 | 476 | 4.21 | 1,250 |
| April 6 | 265 | 811 | 5.46 | 3,100 |
| April 16 | 273 | 1,060 | 6.40 | 5,030 |
| May 3 | 275 | 1,200 | 6.97 | 6,600 |
| May 15 | 281 | 1,530 | 8.15 | 9,620 |
| June 27 | 270 | 1,110 | 6.60 | 5,510 |
| July 10 | 269 | 878 | 5.75 | 3,630 |
| July 19 | 260 | 656 | 4.95 | 2,150 |
| August 2 | 252 | 498 | 4.30 | 1,330 |

*Daily gage height, in feet, of Payette River near Horseshoe Bend, Idaho, in 1906.*

| Day. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 4.1 | 5.65 | 6.8 | 7.1 | 6.5 | 4.35 | 3.9 | 3.8 | 3.95 |
| 2 | | 4.0 | 5.55 | 6.8 | 6.75 | 6.35 | 4.3 | 3.85 | 3.8 | 3.95 |
| 3 | | 4.0 | 5.4 | 7.0 | 6.6 | 6.3 | 4.3 | 3.85 | 3.8 | 3.95 |
| 4 | | 4.05 | 5.45 | 7.15 | 6.8 | 6.25 | 4.25 | 3.85 | 3.75 | 3.95 |
| 5 | | 4.0 | 5.35 | 7.15 | 7.15 | 6.2 | 4.25 | 3.8 | 3.75 | 3.95 |
| 6 | | 4.0 | 5.5 | 7.1 | 7.1 | 6.15 | 4.2 | 3.8 | 3.75 | 3.95 |
| 7 | | 4.0 | 5.8 | 7.1 | 6.9 | 6.05 | 4.2 | 3.8 | 3.75 | 4.0 |
| 8 | | 4.1 | 6.0 | 7.05 | 6.9 | 6.0 | 4.15 | 3.8 | 3.75 | 4.1 |
| 9 | | 4.2 | 6.1 | 7.15 | 6.8 | 5.95 | 4.15 | 3.75 | 3.75 | 4.2 |
| 10 | | 4.3 | 6.5 | 7.4 | 6.7 | 5.85 | 4.1 | 3.75 | 3.75 | 4.25 |

*Daily gage height, in feet, of Payette River, near Horseshoe Bend, Idaho, in 1906*—Cont'd.

| Day. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | ..... | 4.35 | 6.2 | 7.65 | 6.65 | 5.7 | 4.1 | 3.75 | 3.75 | 4.5 |
| 12 | ..... | 4.2 | 6.1 | 8.0 | 7.2 | 5.6 | 4.15 | 3.8 | 3.75 | 5.0 |
| 13 | 3.9 | 4.2 | 6.05 | 8.1 | 7.25 | 5.45 | 4.15 | 3.8 | 3.75 | 6.0 |
| 14 | 3.9 | 4.15 | 6.0 | 8.1 | 7.4 | 5.35 | 4.2 | 3.9 | 3.8 | 6.4 |
| 15 | 4.0 | 4.1 | 6.1 | 8.1 | 7.6 | 5.3 | 4.15 | 4.0 | 3.8 | 6.4 |
| 16 | 4.05 | 4.0 | 6.4 | 8.0 | 7.5 | 5.25 | 4.1 | 4.0 | 3.8 | 6.0 |
| 17 | 4.05 | 4.0 | 6.4 | 7.6 | 7.6 | 5.1 | 4.0 | 4.0 | 3.8 | 5.5 |
| 18 | 4.05 | 4.0 | 6.5 | 7.25 | 7.4 | 5.0 | 4.0 | 3.95 | 3.8 | 6.0 |
| 19 | 4.1 | 4.0 | 6.5 | 7.05 | 7.2 | 4.95 | 4.05 | 3.95 | 3.85 | 5.5 |
| 20 | 4.15 | 4.0 | 6.55 | 6.9 | 7.25 | 4.85 | 4.05 | 3.9 | 3.85 | 5.2 |
| 21 | 4.15 | 4.1 | 6.8 | 6.9 | 7.1 | 4.8 | 4.0 | 3.9 | 3.85 | 5.0 |
| 22 | 4.2 | 4.05 | 7.1 | 6.8 | 6.95 | 4.75 | 4.0 | 3.85 | 3.85 | 4.9 |
| 23 | 4.2 | 4.1 | 7.35 | 6.85 | 6.95 | 4.7 | 4.0 | 3.85 | 3.85 | 4.8 |
| 24 | 4.1 | 4.15 | 7.35 | 6.85 | 6.8 | 4.7 | 4.0 | 3.85 | 3.85 | 4.7 |
| 25 | 4.05 | 4.55 | 7.35 | 6.85 | 6.65 | 4.65 | 4.0 | 3.8 | 3.85 | 4.7 |
| 26 | 4.0 | 4.75 | 7.05 | 6.95 | 6.5 | 4.55 | 4.0 | 3.8 | 3.85 | 4.65 |
| 27 | 4.0 | 4.9 | 6.8 | 7.05 | 6.5 | 4.5 | 4.0 | 3.8 | 3.85 | 4.65 |
| 28 | 4.1 | 5.0 | 6.65 | 7.5 | 7.0 | 4.45 | 3.95 | 3.8 | 3.9 | 4.6 |
| 29 | ..... | 5.05 | 6.65 | 7.5 | 6.9 | 4.45 | 3.95 | 3.8 | 3.9 | 4.6 |
| 30 | ..... | 5.15 | 6.75 | 7.2 | 6.85 | 4.4 | 3.9 | 3.8 | 3.9 | 4.6 |
| 31 | ..... | 5.25 | ..... | 7.25 | ..... | 4.35 | 3.9 | ..... | 3.9 | (a) |

(a) Record discontinued for the winter.

*Rating table for Payette River near Horseshoe Bend, Idaho, for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.70 | 760 | 4.70 | 1,800 | 5.70 | 3,530 | 6.70 | 5,760 | 7.70 | 8,430 |
| 3.80 | 850 | 4.80 | 1,940 | 5.80 | 3,720 | 6.80 | 6,020 | 7.80 | 8,710 |
| 3.90 | 940 | 4.90 | 2,090 | 5.90 | 3,920 | 6.90 | 6,280 | 7.90 | 8,990 |
| 4.00 | 1,030 | 5.00 | 2,250 | 6.00 | 4,120 | 7.00 | 6,540 | 8.00 | 9,270 |
| 4.10 | 1,130 | 5.10 | 2,420 | 6.10 | 4,330 | 7.10 | 6,800 | 8.10 | 9,550 |
| 4.20 | 1,230 | 5.20 | 2,590 | 6.20 | 4,550 | 7.20 | 7,070 | 8.20 | 9,830 |
| 4.30 | 1,330 | 5.30 | 2,770 | 6.30 | 4,780 | 7.30 | 7,340 | | |
| 4.40 | 1,440 | 5.40 | 2,960 | 6.40 | 5,020 | 7.40 | 7,610 | | |
| 4.50 | 1,550 | 5.50 | 3,150 | 6.50 | 5,260 | 7.50 | 7,880 | | |
| 4.60 | 1,670 | 5.60 | 3,340 | 6.60 | 5,510 | 7.60 | 8,150 | | |

NOTE.—The above table is applicable only to open-channel conditions. It is based on 9 discharge measurements made during 1906 and is well defined.

*Monthly discharge of Payette River near Horseshoe Bend, Idaho, for 1906.*

[Drainage area, 2,240 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| February 13–28 | 1,230 | 940 | 1,090 | 34,700 | 0.488 | 0.29 |
| March | 2,680 | 1,030 | 1,930 | 118,000 | .859 | .99 |
| April | 7,480 | 2,860 | 4,960 | 295,000 | 2.21 | 2.47 |
| May | 9,550 | 6,020 | 7,260 | 446,000 | 3.24 | 3.74 |
| June | 8,150 | 5,260 | 6,560 | 390,000 | 2.92 | 3.26 |
| July | 5,260 | 1,380 | 2,900 | 178,000 | 1.30 | 1.50 |
| August | 1,380 | 940 | 1,120 | 69,200 | .502 | .58 |
| September | 1,030 | 805 | 894 | 53,200 | .399 | .44 |
| October | 940 | 805 | 859 | 52,800 | .383 | .44 |
| November | 5,020 | 985 | 2,130 | 127,000 | .952 | 1.06 |
| The period | ..... | ..... | ..... | 1,760,000 | ..... | ..... |

NOTE.—Values are rated as follows: February to August and November, excellent; September and October, good.

## MALHEUR RIVER AT M'LAUGHLIN'S BRIDGE, NEAR VALE, OREG.

This station was established December 10, 1904, and was discontinued December 20, 1906. It is located at the new county bridge, known as McLaughlin's bridge, 10 miles above Vale, Oreg. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 129, where are given also references to publications that contain data for previous years.

*Discharge measurements of Malheur River at McLaughlin's bridge, near Vale, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 3 | R. S. Hall | 81 | 131 | 3.18 | 328 |
| April 26 | do | 153 | 568 | 5.11 | 2,680 |
| November 28 [a] | Stevens and McGlashan | 45 | 120 | 1.71 | 107 |

[a] Channel frozen over above and below bridge.

*Daily gage height, in feet, of Malheur River at McLaughlin Bridge, near Vale, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.60 | 3.62 | 3.55 | 10.06 | 4.25 | 4.00 | 2.40 | 1.35 | 1.25 | 1.65 | 1.90 | 2.35 |
| 2 | 3.60 | 3.62 | 3.25 | 8.28 | 4.15 | 3.62 | 2.30 | 1.35 | 1.30 | 1.65 | 1.90 | 2.35 |
| 3 | 3.60 | 3.62 | 3.20 | 7.85 | 4.10 | 3.65 | 2.30 | 1.30 | 1.30 | 1.70 | 1.95 | 2.35 |
| 4 | 3.60 | 3.62 | 3.15 | 7.25 | 4.05 | 3.60 | 2.25 | 1.25 | 1.40 | 1.70 | 1.95 | 2.35 |
| 5 | 3.60 | 3.62 | 3.20 | 7.80 | 4.00 | 3.60 | 2.25 | 1.20 | 1.35 | 1.70 | 1.95 | 2.35 |
| 6 | 3.60 | 3.62 | 3.20 | 7.40 | 3.95 | 3.75 | 2.25 | 1.20 | 1.40 | 1.70 | 1.95 | 2.4 |
| 7 | 3.60 | 3.62 | 3.30 | 7.70 | 3.95 | 3.70 | 2.15 | 1.15 | 1.40 | 1.70 | 1.95 | 2.4 |
| 8 | 3.60 | 3.62 | 3.80 | 7.92 | 3.85 | 3.60 | 2.15 | 1.15 | 1.45 | 1.70 | 1.95 | 2.4 |
| 9 | 3.60 | 3.62 | 3.90 | 8.08 | 3.75 | 3.58 | 2.15 | 1.15 | 1.45 | 1.70 | 1.95 | 2.4 |
| 10 | 3.60 | 3.62 | 4.20 | 7.98 | 3.65 | 3.55 | 1.90 | 1.15 | 1.45 | 1.70 | 1.95 | 2.3 |
| 11 | 3.60 | 3.70 | 4.10 | 7.40 | 3.60 | 3.55 | 1.90 | 1.00 | 1.45 | 1.70 | 1.95 | 2.2 |
| 12 | 3.60 | 3.70 | 3.63 | 6.85 | 3.60 | 3.30 | 1.90 | 1.00 | 1.50 | 1.70 | 1.95 | 2.2 |
| 13 | 3.60 | 3.70 | 3.50 | 6.10 | 3.65 | 3.30 | 1.80 | 1.00 | 1.50 | 1.70 | 2.00 | 2.2 |
| 14 | 3.60 | 3.70 | 3.35 | 5.90 | 3.60 | 3.25 | 1.75 | 1.00 | 1.55 | 1.65 | 2.00 | 2.2 |
| 15 | 3.60 | 3.70 | 3.25 | 5.95 | 3.55 | 3.20 | 1.75 | 1.00 | 1.55 | 1.65 | 2.00 | 2.15 |
| 16 | 3.60 | 3.70 | 3.25 | 6.00 | 3.52 | 3.20 | 1.65 | 1.00 | 1.55 | 1.65 | 2.00 | 2.15 |
| 17 | 3.60 | 3.70 | 3.20 | 6.15 | 3.50 | 3.15 | 1.65 | 1.00 | 1.60 | 1.70 | 2.00 | 2.15 |
| 18 | 3.60 | 3.70 | 3.15 | 6.15 | 3.45 | 3.00 | 1.60 | 1.00 | 1.60 | 1.70 | 2.00 | 2.15 |
| 19 | 3.60 | 3.75 | 3.15 | 5.80 | 3.30 | 2.90 | 1.55 | 1.05 | 1.60 | 1.75 | 2.05 | 2.15 |
| 20 | 3.60 | 4.24 | 3.15 | 5.38 | 3.15 | 2.85 | 1.52 | 1.05 | 1.65 | 1.75 | 2.10 | ..... |
| 21 | 3.60 | 4.66 | 3.15 | 5.44 | 3.00 | 2.80 | 1.52 | 1.10 | 1.65 | 1.75 | 2.10 | ..... |
| 22 | 3.60 | 4.80 | 3.25 | 5.44 | 3.00 | 2.75 | 1.42 | 1.10 | 1.62 | 1.80 | 2.10 | ..... |
| 23 | 3.60 | 5.32 | 3.85 | 5.38 | 2.90 | 2.50 | 1.50 | 1.15 | 1.60 | 1.80 | 2.10 | ..... |
| 24 | 3.60 | 4.82 | 5.15 | 5.30 | 2.90 | 2.50 | 1.42 | 1.15 | 1.60 | 1.80 | 2.10 | ..... |
| 25 | 3.60 | 4.22 | 7.25 | 5.22 | 2.90 | 2.50 | 1.50 | 1.15 | 1.60 | 1.80 | 2.15 | ..... |
| 26 | 3.60 | 3.40 | 7.38 | 5.09 | 2.85 | 2.50 | 1.42 | 1.15 | 1.60 | 1.80 | 2.15 | ..... |
| 27 | 3.60 | 3.40 | 7.40 | 5.04 | 2.85 | 2.50 | 1.42 | 1.20 | 1.65 | 1.80 | 2.20 | ..... |
| 28 | 3.60 | 3.38 | 7.40 | 4.72 | 3.90 | 2.50 | 1.42 | 1.20 | 1.65 | 1.80 | 2.20 | ..... |
| 29 | 3.60 | ..... | 7.30 | 4.50 | 4.10 | 2.50 | 1.40 | 1.25 | 1.65 | 1.80 | 2.22 | ..... |
| 30 | 3.60 | ..... | 8.04 | 4.25 | 4.70 | 2.50 | 1.40 | 1.25 | 1.65 | 1.85 | 2.30 | ..... |
| 31 | 3.60 | ..... | 9.88 | ..... | 4.65 | ..... | 1.40 | 1.25 | ..... | 1.90 | ..... | ..... |

NOTE.—The following ice conditions prevailed during 1906: River frozen over January 1 to February 22; gage heights are to the top of ice. On February 22 an ice jam formed at the bridge; this went out February 25. November 13 to 18, slush ice was running in the morning; the gage heights were taken in the afternoon, and were probably not affected. November 19 there was ice along edges and anchor ice in the bottom; this ice went out December 11. December 14 to 19 ice formed at night, but went out in the daytime, and probably did not affect gage heights.

*Rating tables for Malheur River at McLaughlin's Bridge, near Vale, Oreg.*

JANUARY 1 TO MARCH 31, 1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.00 | 270 | 3.80 | 755 | 4.60 | 1,380 | 5.40 | 2,125 | 6.40 | 3,610 |
| 3.10 | 320 | 3.90 | 825 | 4.70 | 1,465 | 5.50 | 2,245 | 6.60 | 3,970 |
| 3.20 | 375 | 4.00 | 900 | 4.80 | 1,550 | 5.60 | 2,370 | 6.80 | 4,350 |
| 3.30 | 430 | 4.10 | 975 | 4.90 | 1,635 | 5.70 | 2,500 | 7.00 | 4,750 |
| 3.40 | 490 | 4.20 | 1,055 | 5.00 | 1,720 | 5.80 | 2,640 | 8.00 | 7,200 |
| 3.50 | 550 | 4.30 | 1,135 | 5.10 | 1,810 | 5.90 | 2,790 | 9.00 | 10,200 |
| 3.60 | 615 | 4.40 | 1,215 | 5.20 | 1,910 | 6.00 | 2,950 | 10.00 | 13,250 |
| 3.70 | 685 | 4.50 | 1,295 | 5.30 | 2,015 | 6.20 | 3,270 | | |

APRIL 1 TO DECEMBER 20, 1906.[b]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.00 | 5 | 1.90 | 215 | 2.80 | 630 | 3.70 | 1,245 | 5.20 | 2,810 |
| 1.10 | 20 | 2.00 | 250 | 2.90 | 690 | 3.80 | 1,325 | 5.40 | 3,090 |
| 1.20 | 37 | 2.10 | 290 | 3.00 | 750 | 3.90 | 1,410 | 5.60 | 3,380 |
| 1.30 | 56 | 2.20 | 330 | 3.10 | 815 | 4.00 | 1,500 | 5.80 | 3,680 |
| 1.40 | 77 | 2.30 | 375 | 3.20 | 880 | 4.20 | 1,690 | 6.00 | 4,000 |
| 1.50 | 100 | 2.40 | 420 | 3.30 | 950 | 4.40 | 1,890 | 7.00 | 5,900 |
| 1.60 | 125 | 2.50 | 470 | 3.40 | 1,020 | 4.60 | 2,090 | 8.20 | 8,150 |
| 1.70 | 155 | 2.60 | 520 | 3.50 | 1,090 | 4.80 | 2,310 | 9.30 | 10,650 |
| 1.80 | 185 | 2.70 | 575 | 3.60 | 1,165 | 5.00 | 2,550 | 10.40 | 13,250 |

[a] This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905-6, and is well defined below gage heights 5 feet. The table has been extended by subtracting the discharge of Bully Creek for April 1 from the discharge at Vale.

[b] This table is applicable only for open-channel conditions. It is based on 1 discharge measurement made during 1906 and on the form of the previous curve, and is not well defined.

*Monthly discharge of Malheur River at McLaughlin Bridge, near Vale, Oreg., for 1906.*

[Drainage area, 4,150 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| March | 12,900 | 348 | 2,000 | 123,000 | 0.482 | 0.56 |
| April | 13,400 | 1,740 | 5,100 | 303,000 | 1.23 | 1.37 |
| May | 2,200 | 660 | 1,220 | 75,000 | .294 | .34 |
| June | 1,500 | 470 | 851 | 50,600 | .205 | .23 |
| July | 420 | 77 | 190 | 11,700 | .046 | .05 |
| August | 66 | 5 | 27.4 | 1,680 | .0066 | .01 |
| September | 140 | 46 | 106 | 6,310 | .026 | .03 |
| October | 215 | 140 | 165 | 10,100 | .040 | .05 |
| November 1–18 | 250 | 215 | 236 | 8,430 | .057 | .04 |
| December 11–19 | 330 | 310 | 319 | 5,690 | .077 | .03 |
| The period | | | | 611,000 | | |

NOTE.—Values are rated as follows: March to June, fair; July to December, approximate.

## MALHEUR RIVER AT VALE, OREG.

This station was established May 20, 1903, at the steel highway bridge one-eighth mile southeast of Vale, Oreg., where a station has been maintained at intervals since 1890. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 126, where are given also references to publications that contain data for previous years.

*Discharge measurements of Malheur River at Vale, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 29 | R. S. Hall | 102 | 175 | 4.45 | 212 |
| February 15 | do | 103 | 174 | 4.42 | 197 |
| February 16 | do | 104 | 185 | 4.49 | 228 |
| March 2 | do | 122 | 230 | 4.93 | 432 |
| March 24 | do | 149 | 599 | 6.83 | 1,990 |
| March 25 | do | 165 | 986 | 9.30 | 5,300 |
| March 29 | do | 162 | 1,010 | 9.54 | 5,310 |
| April 9 | do | 165 | 1,220 | 10.82 | 7,190 |
| April 24 | do | 146 | 792 | 7.58 | 2,840 |
| April 26 | do | 144 | 746 | 7.40 | 2,670 |
| May 4 | do | 127 | 474 | 6.12 | 1,250 |
| June 14 | do | 117 | 292 | 5.14 | 591 |

*Daily gage height, in feet, of Malheur River at Vale, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.39 | 4.37 | 5.23 | 14.34 | 6.36 | 6.36 | 4.30 | 3.44 | 3.40 | 3.68 | 3.90 | 4.01 |
| 2 | 4.16 | 4.35 | 4.95 | 11.55 | 6.26 | 5.88 | 4.26 | 3.40 | 3.40 | 3.68 | 3.92 | 4.01 |
| 3 | 4.14 | 4.31 | 4.78 | 9.82 | 6.20 | 5.61 | 4.18 | 3.40 | 3.41 | 3.71 | 3.93 | 3.98 |
| 4 | 4.46 | 4.30 | 4.75 | 9.52 | 6.12 | 5.50 | 4.14 | 3.36 | 3.42 | 3.72 | 3.94 | 3.96 |
| 5 | 4.48 | 4.31 | 4.74 | 9.50 | 6.02 | 5.58 | 4.12 | 3.33 | 3.44 | 3.73 | 3.98 | 3.97 |
| 6 | 4.34 | 4.66 | 4.84 | 9.88 | 5.95 | 5.88 | 4.10 | 3.32 | 3.51 | 3.72 | 3.99 | 3.98 |
| 7 | 4.49 | 4.50 | 4.87 | 10.51 | 5.89 | 5.76 | 4.03 | 3.29 | 3.48 | 3.74 | 4.02 | 4.02 |
| 8 | 4.24 | 4.32 | 5.36 | 10.62 | 5.76 | 5.85 | 3.96 | 3.29 | 3.50 | 3.74 | 4.02 | 4.12 |
| 9 | 4.16 | 4.43 | 5.80 | 10.86 | 5.64 | 5.75 | 3.94 | 3.28 | 3.51 | 3.73 | 4.04 | 4.22 |
| 10 | 4.18 | 4.27 | 6.10 | 10.54 | 5.56 | 5.57 | 3.90 | 3.26 | 3.49 | 3.72 | 4.08 | 4.21 |
| 11 | 4.19 | 4.27 | 6.35 | 9.86 | 5.51 | 5.46 | 3.82 | 3.26 | 3.50 | 3.73 | 4.04 | 4.22 |
| 12 | 4.20 | 4.28 | 6.07 | 8.93 | 5.61 | 5.38 | 3.76 | 3.30 | 3.51 | 3.74 | 4.04 | 4.21 |
| 13 | 4.20 | 4.31 | 5.56 | 8.52 | 5.62 | 5.24 | 3.72 | 3.25 | 3.50 | 3.74 | 4.03 | 4.23 |
| 14 | 4.22 | 4.36 | 5.18 | 8.30 | 5.52 | 5.18 | 3.66 | 3.24 | 3.50 | 3.70 | 4.03 | 4.22 |
| 15 | 4.28 | 4.41 | 5.34 | 8.44 | 5.40 | 5.10 | 3.62 | 3.25 | 3.54 | 3.72 | 4.05 | 4.24 |
| 16 | 4.20 | 4.49 | 5.27 | 8.49 | 5.38 | 5.04 | 3.55 | 3.25 | 3.58 | 3.73 | 4.06 | 4.20 |
| 17 | 4.38 | 4.52 | 4.68 | 8.62 | 5.32 | 4.98 | 3.50 | 3.25 | 3.58 | 3.74 | 4.06 | 4.15 |
| 18 | 4.24 | 4.52 | 4.55 | 8.54 | 5.26 | 4.87 | 3.50 | 3.24 | 3.59 | 3.74 | 4.05 | 4.17 |
| 19 | 4.25 | 4.54 | 4.55 | 8.23 | 5.16 | 4.87 | 3.51 | 3.21 | 3.64 | 3.75 | 4.04 | 4.22 |
| 20 | 4.38 | 4.80 | 4.76 | 7.90 | 5.04 | 4.75 | 3.49 | 3.20 | 3.63 | 3.77 | 4.11 | 4.20 |
| 21 | 4.54 | 5.28 | 4.76 | 7.82 | 4.98 | 4.68 | 3.48 | 3.20 | 3.64 | 3.77 | 4.12 | 4.17 |
| 22 | 4.36 | 5.23 | 4.80 | 7.79 | 4.90 | 4.60 | 3.34 | 3.20 | 3.66 | 3.81 | 4.07 | 4.24 |
| 23 | 4.36 | 5.51 | 5.09 | 7.75 | 4.83 | 4.53 | 3.37 | 3.18 | 3.64 | 3.88 | 4.00 | 4.21 |
| 24 | 4.34 | 5.21 | 6.98 | 7.58 | 4.78 | 4.44 | 3.20 | 3.20 | 3.64 | 3.90 | 3.92 | 4.22 |
| 25 | 4.33 | 5.22 | 9.36 | 7.47 | 4.72 | 4.38 | 3.38 | 3.22 | 3.64 | 3.92 | 3.88 | 4.22 |
| 26 | 4.65 | 4.90 | 9.48 | 7.38 | 4.68 | 4.38 | 3.34 | 3.28 | 3.63 | 3.94 | 3.92 | 4.22 |
| 27 | 4.42 | 4.82 | 9.53 | 7.22 | 4.64 | 4.31 | 3.39 | 3.30 | 3.66 | 3.91 | 4.00 | 4.26 |
| 28 | 4.46 | 4.90 | 9.82 | 6.96 | 4.80 | 4.27 | 3.50 | 3.31 | 3.65 | 3.90 | 4.16 | 4.48 |
| 29 | 4.47 | ..... | 9.45 | 6.60 | 5.16 | 4.22 | 3.50 | 3.34 | 3.64 | 3.90 | 4.12 | 4.69 |
| 30 | 4.42 | ..... | 10.28 | 6.44 | 6.80 | 4.32 | 3.50 | 3.31 | 3.65 | 3.89 | 4.03 | 4.58 |
| 31 | 4.38 | ..... | 12.75 | ..... | 6.93 | ..... | 3.50 | 3.39 | ..... | 3.90 | ..... | 4.50 |

NOTE.—River frozen two-thirds across November 22. Ice conditions until December 20. Ice attained a maximum thickness of 10 inches.

*Rating table for Malheur River at Vale, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.20 | 5 | 4.40 | 195 | 5.50 | 810 | 6.70 | 1,840 | 8.80 | 4,330 |
| 3.30 | 9 | 4.50 | 235 | 5.60 | 880 | 6.80 | 1,940 | 9.00 | 4,600 |
| 3.40 | 14 | 4.60 | 280 | 5.70 | 955 | 6.90 | 2,045 | 9.20 | 4,870 |
| 3.50 | 21 | 4.70 | 325 | 5.80 | 1,030 | 7.00 | 2,150 | 9.40 | 5,150 |
| 3.60 | 29 | 4.80 | 375 | 5.90 | 1,110 | 7.20 | 2,370 | 9.60 | 5,430 |
| 3.70 | 39 | 4.90 | 430 | 6.00 | 1,190 | 7.40 | 2,595 | 9.80 | 5,710 |
| 3.80 | 52 | 5.00 | 490 | 6.10 | 1,275 | 7.60 | 2,825 | 10.00 | 6,000 |
| 3.90 | 67 | 5.10 | 550 | 6.20 | 1,360 | 7.80 | 3,060 | 11.00 | 7,470 |
| 4.00 | 85 | 5.20 | 610 | 6.30 | 1,450 | 8.00 | 3,300 | 12.00 | 8,970 |
| 4.10 | 105 | ..... | ..... | 6.40 | 1,545 | 8.20 | 3,550 | 13.00 | 10,570 |
| 4.20 | 130 | 5.30 | 675 | 6.50 | 1,640 | 8.40 | 3,810 | 14.00 | 12,220 |
| 4.30 | 160 | 5.40 | 740 | 6.60 | 1,740 | 8.60 | 4,070 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 12 discharge measurements made during 1906 and is well defined between gage heights 4.4 feet and 11.0 feet.

*Monthly discharge of Malheur River at Vale, Oreg., for 1906.*

[Drainage area, 4,860 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 302 | 115 | 174 | 10,700 | 0.036 | 0.04 |
| February | 817 | 151 | 311 | 17,300 | .064 | .07 |
| March | 10,200 | 258 | 1,920 | 118,000 | .395 | .46 |
| April | 12,800 | 1,580 | 4,550 | 271,000 | .936 | 1.04 |
| May | 2,080 | 298 | 862 | 53,000 | .177 | .20 |
| June | 1,510 | 136 | 589 | 35,000 | .121 | .14 |
| July | 160 | 5 | 49.7 | 3,060 | .010 | .01 |
| August | 17 | 4 | 8.6 | 529 | .0018 | .002 |
| September | 35 | 14 | 25.7 | 1,530 | .0053 | .01 |
| October | 74 | 37 | 50.5 | 3,110 | .010 | .01 |
| November | 120 | 64 | 89.3 | 5,310 | .018 | .02 |
| December | 320 | 78 | 138 | 8,480 | .028 | .03 |
| The year | 12,800 | 4 | 731 | 527,000 | .150 | 2.03 |

NOTE.—Values are rated as follows: January, November, and December, good; February to June, excellent; July, September, and October, fair; August, approximate.

## MIDDLE FORK OF MALHEUR RIVER AT RIVERSIDE, OREG.

This station was established January 24, 1906, and was discontinued December 31, 1906, on account of the expense of maintenance. It was located one-half mile above Riverside post-office, and 200 feet above the mouth of South Fork.

The channel is straight; the banks are high and steep. The bed is of gravel and liable to change. There is one channel at all stages.

Discharge measurements were made from a cable.

A chain gage, which was read by J. C. Bloylock, was installed May 8, 1906; length of chain, 15.12 feet. Gage heights previous to this were reduced to the same datum. The bench mark is the highest point of a rock on the left bank near the cable supports, marked B. M.; elevation, 19.41 feet above the gage datum.

The following measurement was made May 9, 1906:

Width, 86 feet; area, 156 feet; gage height, 2.18 feet; discharge, 495 second-feet.

*Daily gage height, in feet, of Middle Fork of Malheur River at Riverside, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 1.9 | ..... | 6.75 | 2.2 | 2.2 | 1.4 | 0.6 | 0.6 | 0.9 | 0.9 | 1.2 |
| 2 | ..... | 1.9 | ..... | ..... | 2.2 | 2.1 | 1.4 | .6 | .6 | .9 | 1.1 | 1.2 |
| 3 | 1.9 | 1.6 | ..... | ..... | 2.2 | 2.1 | 1.4 | .6 | .6 | .9 | 1.1 | 1.3 |
| 4 | 1.9 | 1.6 | ..... | 6.35 | 2.2 | 2.2 | 1.3 | .5 | .6 | .9 | 1.1 | 1.2 |
| 5 | 1.9 | 1.7 | ..... | ..... | 2.2 | 2.3 | 1.2 | .5 | .6 | .9 | 1.1 | 1.3 |
| 6 | 1.9 | 1.8 | ..... | ..... | 2.2 | 2.2 | 1.2 | .5 | .6 | .9 | 1.1 | 1.2 |
| 7 | 1.9 | 1.8 | ..... | ..... | 2.2 | 2.2 | 1.1 | .5 | .6 | .9 | 1.1 | 1.2 |
| 8 | 1.9 | 1.7 | ..... | 6.35 | 2.1 | 2.1 | 1.1 | .5 | .6 | .9 | 1.1 | 1.2 |
| 9 | 1.9 | 1.7 | ..... | 6.35 | 2.2 | 2.1 | 1.1 | .5 | .6 | .9 | 1.1 | 1.2 |
| 10 | 1.9 | 1.8 | 2.0 | 6.35 | 2.2 | 2.1 | 1.1 | .5 | .6 | 1.0 | 1.1 | 1.2 |
| 11 | 2.0 | 1.8 | 1.9 | 6.35 | 2.2 | 2.1 | 1.0 | .5 | .6 | 1.0 | 1.1 | 1.2 |
| 12 | 2.1 | 1.9 | 1.8 | ..... | 2.1 | 2.0 | 1.0 | .5 | .6 | 1.0 | 1.1 | 1.2 |
| 13 | 2.1 | 1.9 | 1.7 | ..... | 2.2 | 2.0 | 1.0 | .5 | .6 | 1.2 | 1.1 | 1.2 |
| 14 | 2.1 | 1.8 | 1.6 | ..... | 2.1 | 1.9 | 1.0 | .5 | .7 | 1.2 | 1.1 | 1.1 |
| 15 | 2.1 | 1.85 | ..... | ..... | 2.1 | 1.9 | .9 | .5 | .8 | .9 | 1.1 | 1.2 |
| 16 | 2.1 | 1.9 | ..... | ..... | 2.1 | 1.9 | .9 | .55 | .7 | .9 | 1.1 | 1.2 |
| 17 | 2.1 | 1.7 | ..... | ..... | 2.0 | 1.8 | 1.0 | .5 | .7 | 1.0 | 1.2 | 1.2 |
| 18 | 2.2 | 1.7 | ..... | ..... | 2.0 | 1.8 | 1.0 | .5 | .7 | 1.0 | 1.2 | 1.2 |
| 19 | 2.3 | 1.7 | ..... | ..... | 1.9 | 1.7 | .9 | .5 | .7 | 1.0 | 1.2 | 1.2 |
| 20 | 2.3 | 1.6 | ..... | 3.3 | 1.8 | 1.7 | .9 | .5 | .7 | 1.0 | 1.2 | 1.2 |
| 21 | 2.4 | 1.7 | ..... | 3.5 | 1.8 | 1.6 | .9 | .5 | .7 | 1.0 | 1.1 | 1.2 |
| 22 | 2.0 | 1.6 | 1.8 | 3.4 | 1.7 | 1.6 | .9 | .5 | .8 | 1.0 | 1.1 | 1.2 |
| 23 | ..... | 1.3 | 2.1 | 3.4 | 1.7 | 1.6 | .9 | .5 | .8 | 1.0 | 1.4 | 1.2 |
| 24 | 2.0 | 1.1 | 3.75 | 3.0 | 1.7 | 1.5 | .9 | .5 | .8 | 1.0 | 1.5 | 1.2 |
| 25 | 2.0 | 1.1 | 4.1 | 2.9 | 1.7 | 1.4 | .8 | .5 | .8 | 1.0 | 1.4 | 1.3 |
| 26 | 2.0 | ..... | 3.8 | 2.9 | 1.6 | 1.4 | .8 | .5 | .8 | 1.0 | 1.4 | 1.7 |
| 27 | 2.1 | ..... | 4.15 | 2.7 | 1.8 | 1.6 | .8 | .5 | .8 | 1.0 | 1.3 | 1.8 |
| 28 | 2.1 | ..... | 4.2 | 2.6 | 2.1 | 1.5 | .8 | .5 | .9 | 1.0 | 1.2 | 1.6 |
| 29 | 2.0 | ..... | 4.2 | 2.4 | 2.5 | 1.4 | .7 | .6 | .9 | 1.0 | 1.2 | 1.5 |
| 30 | 2.0 | ..... | 6.75 | 2.2 | 2.8 | 1.5 | .7 | .6 | .9 | 1.0 | 1.2 | 1.5 |
| 31 | 1.9 | ..... | ..... | ..... | 2.5 | ..... | .7 | .6 | ..... | .9 | ..... | 1.3 |

## BULLY CREEK ABOVE VALE, OREG.

This station was established January 27, 1905. It is near the location of the original station on Bully Creek, one-fourth mile below Warm Springs stage station, 15 miles above Vale, Oreg. To replace the former bench mark, which had been destroyed, a new one was established May 6, 1906, as follows: A small shoulder cut in rock on upper side of road 6.2 feet upstream from gage; elevation, 6.82 feet above gage datum. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 137, where are given also references to publications that contain data for previous years.

*Discharge measurements of Bully Creek above Vale, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 28 | R. S. Hall | 13 | 6.7 | 2.03 | 7.8 |
| March 26 | do | 77 | 128 | 3.98 | 579 |
| March 27 | do | 78 | 176 | 4.60 | 1,100 |
| March 28 | do | 79 | 151 | 4.19 | 826 |
| March 29 | do | 79 | 172 | 4.58 | 1,010 |
| April 10 | do | 78 | 123 | 3.88 | 704 |
| April 11 | do | 68 | 115 | 3.70 | 567 |
| May 5 | do | 39 | 43 | 2.00 | 52 |
| June 15 | do | 33 | 35 | 1.70 | 20 |

*Daily gage height, in feet, of Bully Creek above Vale, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.18 | 2.18 | 2.14 | 5.00 | 2.50 | 2.18 | 1.46 | 1.30 | 1.30 | 1.30 | 1.30 | 1.50 |
| 2 | 2.18 | 2.20 | 2.14 | 4.20 | 2.40 | 2.12 | 1.50 | 1.30 | 1.30 | 1.30 | 1.30 | 1.50 |
| 3 | 2.16 | 2.24 | 2.16 | 4.00 | 2.30 | 2.12 | 1.50 | 1.30 | 1.30 | 1.30 | 1.30 | 1.50 |
| 4 | 2.15 | 2.26 | 2.18 | 3.70 | 2.20 | 2.14 | 1.50 | 1.30 | 1.30 | 1.30 | 1.30 | 1.50 |
| 5 | 2.12 | 2.28 | 2.20 | 4.20 | 2.00 | 2.18 | 1.50 | 1.30 | 1.30 | 1.30 | 1.30 | 1.52 |
| 6 | 2.12 | 2.30 | 2.20 | 4.50 | 2.00 | 2.18 | 1.50 | 1.30 | 1.30 | 1.30 | 1.30 | 1.52 |
| 7 | 2.12 | 2.26 | 2.30 | 4.30 | 1.96 | 2.18 | 2.00 | 1.30 | 1.30 | 1.30 | 1.32 | 1.52 |
| 8 | 2.14 | 2.20 | 2.36 | 4.00 | 1.90 | 2.10 | 1.80 | 1.30 | 1.30 | 1.30 | 1.32 | 1.54 |
| 9 | 2.14 | 2.10 | 2.65 | 4.30 | 1.80 | 2.00 | 1.70 | 1.30 | 1.30 | 1.30 | 1.34 | 1.54 |
| 10 | 2.16 | 2.08 | 2.80 | 3.80 | 1.76 | 1.90 | 1.60 | 1.30 | 1.30 | 1.30 | 1.34 | 1.56 |
| 11 | 2.16 | 2.00 | 2.60 | 3.60 | 2.10 | 1.86 | 1.52 | 1.30 | 1.30 | 1.30 | 1.36 | 1.56 |
| 12 | 2.16 | 2.00 | 2.60 | 3.50 | 2.18 | 1.84 | 1.50 | 1.30 | 1.30 | 1.30 | 1.40 | 1.56 |
| 13 | 2.16 | 2.00 | 2.60 | 3.30 | 2.18 | 1.80 | 1.44 | 1.30 | 1.30 | 1.30 | 1.44 | 1.54 |
| 14 | 2.16 | 2.08 | 2.58 | 3.30 | 2.10 | 1.70 | 1.40 | 1.30 | 1.30 | 1.30 | 1.46 | 1.54 |
| 15 | 2.14 | 2.10 | 2.54 | 3.20 | 2.00 | 1.60 | 1.40 | 1.30 | 1.30 | 1.30 | 1.46 | 1.54 |
| 16 | 2.14 | 2.10 | 2.40 | 3.20 | 2.00 | 1.64 | 1.40 | 1.30 | 1.30 | 1.30 | 1.48 | 1.52 |
| 17 | 2.12 | 2.10 | 2.40 | 3.10 | 1.90 | 1.70 | 1.40 | 1.30 | 1.30 | 1.30 | 1.48 | 1.52 |
| 18 | 2.12 | 2.10 | 2.40 | 3.10 | 1.90 | 1.70 | 1.40 | 1.30 | 1.30 | 1.30 | 1.48 | 1.54 |
| 19 | 2.10 | 2.10 | 2.50 | 3.00 | 1.80 | 1.70 | 1.40 | 1.30 | 1.30 | 1.30 | 1.50 | 1.54 |
| 20 | 2.08 | 2.10 | 2.50 | 3.00 | 1.80 | 1.68 | 1.40 | 1.30 | 1.30 | 1.30 | 1.50 | 1.54 |
| 21 | 2.06 | 2.10 | 2.54 | 3.00 | 1.80 | 1.68 | 1.40 | 1.30 | 1.30 | 1.30 | 1.50 | 1.56 |
| 22 | 2.08 | 2.10 | 2.80 | 3.00 | 1.78 | 1.66 | 1.40 | 1.30 | 1.30 | 1.30 | 1.50 | 1.56 |
| 23 | 2.08 | 2.10 | 3.00 | 2.80 | 1.78 | 1.64 | 1.40 | 1.30 | 1.30 | 1.30 | 1.50 | 1.56 |
| 24 | 2.10 | 2.10 | 4.30 | 2.80 | 1.74 | 1.64 | 1.38 | 1.30 | 1.30 | 1.30 | 1.50 | 1.56 |
| 25 | 2.10 | 2.10 | 4.10 | 2.80 | 1.74 | 1.60 | 1.36 | 1.30 | 1.30 | 1.30 | 1.50 | 1.56 |
| 26 | 2.10 | 2.10 | 4.10 | 2.60 | 1.72 | 1.60 | 1.34 | 1.30 | 1.30 | 1.30 | 1.50 | 1.56 |
| 27 | 2.10 | 2.12 | 4.50 | 2.60 | 1.72 | 1.58 | 1.30 | 1.30 | 1.30 | 1.30 | 1.50 | 1.56 |
| 28 | 2.12 | 2.10 | 4.30 | 2.60 | 1.72 | 1.58 | 1.30 | 1.30 | 1.30 | 1.30 | 1.50 | 1.56 |
| 29 | 2.12 | ..... | 4.30 | 2.60 | 1.80 | 1.56 | 1.30 | 1.30 | 1.30 | 1.30 | 1.50 | 1.56 |
| 30 | 2.14 | ..... | 4.90 | 2.50 | 2.20 | 1.50 | 1.30 | 1.30 | 1.30 | 1.30 | 1.50 | 1.54 |
| 31 | 2.16 | ..... | 6.10 | ..... | 2.20 | ..... | ..... | 1.30 | ..... | 1.30 | ..... | 1.52 |

NOTE.—Creek was frozen December 12 to 31; discharges not corrected.

*Rating tables for Bully Creek above Vale, Oreg.*

JANUARY 1 TO MARCH 31, 1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.60 | 0.0 | 2.40 | 42 | 3.20 | 238 | 4.00 | 620 | 4.80 | 1,195 |
| 1.70 | .3 | 2.50 | 56 | 3.30 | 274 | 4.10 | 680 | 4.90 | 1,275 |
| 1.80 | 2 | 2.60 | 74 | 3.40 | 313 | 4.20 | 745 | 5.00 | 1,360 |
| 1.90 | 6 | 2.70 | 96 | 3.50 | 355 | 4.30 | 815 | 5.20 | 1,540 |
| 2.00 | 11 | 2.80 | 120 | 3.60 | 400 | 4.40 | 885 | 5.40 | 1,750 |
| 2.10 | 17 | 2.90 | 146 | 3.70 | 450 | 4.50 | 960 | 5.60 | 1,980 |
| 2.20 | 24 | 3.00 | 174 | 3.80 | 505 | 4.60 | 1,035 | 5.80 | 2,230 |
| 2.30 | 32 | 3.10 | 205 | 3.90 | 560 | 4.70 | 1,115 | 6.00 | 2,500 |

APRIL 1 TO DECEMBER 31, 1906.[b]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.30 | 3 | 2.00 | 50 | 2.70 | 190 | 3.40 | 425 | 4.20 | 845 |
| 1.40 | 4 | 2.10 | 65 | 2.80 | 215 | 3.50 | 470 | 4.40 | 975 |
| 1.50 | 7 | 2.20 | 80 | 2.90 | 245 | 3.60 | 515 | 4.60 | 1,110 |
| 1.60 | 12 | 2.30 | 100 | 3.00 | 275 | 3.70 | 565 | 4.80 | 1,250 |
| 1.70 | 19 | 2.40 | 120 | 3.10 | 310 | 3.80 | 615 | 5.00 | 1,400 |
| 1.80 | 28 | 2.50 | 140 | 3.20 | 345 | 3.90 | 670 | | |
| 1.90 | 38 | 2.60 | 165 | 3.30 | 385 | 4.00 | 725 | | |

[a] This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is not well defined.

[b] This table is applicable only for open-channel conditions. It is based on 4 discharge measurements made during 1906 and is fairly well defined.

*Monthly discharge of Bully Creek above Vale, Oreg., for 1906.*

[Drainage area, 650 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 23 | 15 | 18.9 | 1,160 | 0.029 | 0.03 |
| February | 32 | 11 | 19.2 | 1,070 | .030 | .03 |
| March | 2,640 | 20 | 324 | 19,900 | .498 | .57 |
| April | 1,400 | 140 | 473.0 | 28,100 | .728 | .81 |
| May | 140 | 21 | 50.6 | 3,110 | .078 | .09 |
| June | 77 | 7 | 33.7 | 2,010 | .052 | .06 |
| July | 50 | 3 | 7.61 | 468 | .012 | .01 |
| August | 3 | 3 | 3.0 | 184 | .0046 | .01 |
| September | 3 | 3 | 3.0 | 179 | .0046 | .01 |
| October | 3 | 3 | 3.0 | 184 | .0046 | .01 |
| November | 7 | 3 | 5.23 | 311 | .0080 | .01 |
| December | 10 | 7 | 8.94 | 550 | .014 | .02 |
| The year | 2,640 | 3 | 79.2 | 57,200 | .122 | 1.66 |

NOTE.—Values are rated as follows: January to March and July to December, approximate; April to June, good.

## BULLY CREEK AT VALE, OREG.

This station was discontinued as a permanent gaging station on December 31, 1905. The conditions and the bench marks are described in Water-Supply Paper No. 178, page 140, where are given also references to publications that contain data for previous years.

A number of measurements were made during 1906, as follows:

*Discharge measurements of Bully Creek at Vale, Oreg., in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. | Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 29 | 15 | 6.7 | 3.22 | 8.5 | March 24 | 45 | 97 | 5.52 | 435 |
| February 15 | 14 | 8.3 | 3.30 | 11 | November 28[a] | ..... | ..... | ..... | 3 |
| March 3 | 14 | 10 | 3.36 | 16 | | | | | |

[a] Estimated at low water; frozen.

## WILLOW CREEK NEAR MALHEUR, OREG.

This station was established November 4, 1904, and was discontinued August 15, 1906. It is located at Beer's ranch, about 5 miles from Malheur, on the road to Huntington, Oreg. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 141, where are given also references to publications that contain data for previous years.

The following measurement was made April 5, 1906:

Width, 36 feet; area, 79 square feet; gage height, 4.75 feet; discharge, 355 second-feet.

*Daily gage height, in feet, of Willow Creek near Malheur, Oreg., for 1906.*

| Day. | Mar. | Apr. | May. | June. | July. | Aug. | Day. | Mar. | Apr. | May. | June. | July. | Aug. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 5.0 | 1.9 | 1.9 | 1.0 | 0.2 | 17 | | 2.9 | 0.8 | 1.5 | | |
| 2 | | 4.0 | 1.9 | 1.8 | 1.0 | | 18 | | 2.9 | .8 | 1.25 | | |
| 3 | | 3.9 | 1.8 | 1.8 | 1.0 | | 19 | | 2.7 | .8 | 1.0 | | |
| 4 | | 5.0 | 1.5 | 1.7 | | .2 | 20 | | 2.8 | 1.3 | .9 | 0.4 | |
| 5 | | 5.1 | 1.3 | 1.7 | .7 | .2 | 21 | | 2.7 | 1.4 | .95 | .4 | |
| 6 | | 5.1 | 1.3 | 1.8 | .7 | .2 | 22 | | 2.6 | 1.4 | .5 | .4 | |
| 7 | | 5.1 | 1.2 | 1.9 | .7 | .2 | 23 | 1.3 | 2.6 | 1.8 | .6 | .4 | |
| 8 | | 4.7 | 1.2 | 1.9 | .7 | .2 | 24 | 3.8 | 2.5 | 1.8 | .5 | | |
| 9 | | 4.3 | 1.2 | 1.9 | .7 | .2 | 25 | 2.5 | 2.5 | 1.9 | .5 | | |
| 10 | | 4.0 | 1.2 | 1.3 | .7 | .2 | 26 | 2.5 | 2.5 | 1.9 | .8 | | |
| 11 | | 3.7 | 1.0 | 1.4 | .65 | | 27 | 3.0 | 2.5 | 1.9 | .9 | .4 | |
| 12 | | 3.3 | 1.0 | | .65 | | 28 | 3.0 | 2.4 | 1.9 | .9 | .3 | |
| 13 | | 3.0 | 1.0 | | .65 | .2 | 29 | 3.5 | 2.3 | 1.9 | .8 | .3 | |
| 14 | | 2.9 | .9 | 1.3 | .8 | .2 | 30 | 4.1 | 2.1 | 1.9 | 1.0 | | |
| 15 | | 2.9 | .9 | 1.3 | .7 | | 31 | 4.7 | | 1.9 | | | |
| 16 | | 2.9 | .9 | 1.3 | .55 | | | | | | | | |

*Rating table for Willow Creek near Malheur, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.20 | 0 | 1.10 | 16 | 2.00 | 64 | 2.90 | 137 | 3.80 | 235 |
| .30 | .5 | 1.20 | 20 | 2.10 | 71 | 3.00 | 147 | 3.90 | 247 |
| .40 | 1.2 | 1.30 | 24 | 2.20 | 78 | 3.10 | 157 | 4.00 | 259 |
| .50 | 2.2 | 1.40 | 29 | 2.30 | 86 | 3.20 | 167 | 4.20 | 283 |
| .60 | 3.5 | 1.50 | 34 | 2.40 | 94 | 3.30 | 178 | 4.40 | 309 |
| .70 | 5.0 | 1.60 | 39 | 2.50 | 102 | 3.40 | 189 | 4.60 | 335 |
| .80 | 7.0 | 1.70 | 45 | 2.60 | 110 | 3.50 | 200 | 4.80 | 361 |
| .90 | 9.5 | 1.80 | 51 | 2.70 | 119 | 3.60 | 211 | 5.00 | 388 |
| 1.00 | 12.5 | 1.90 | 57 | 2.80 | 128 | 3.70 | 223 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is fairly well defined below gage height 2 feet.

*Monthly discharge of Willow Creek near Malheur, Oreg., for 1906.*

[Drainage area, 259 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| March 23–31 | 348 | 24 | 175 | 3,120 | 0.676 | 0.23 |
| April | 402 | 71 | 196 | 11,700 | .757 | .84 |
| May | 57 | 7 | 32.2 | 1,980 | .124 | .14 |
| June | 57 | 2.2 | 26.5 | 1,580 | .102 | .11 |
| July | 12.5 | 0 | 3.90 | 240 | .015 | .02 |
| August 1–14 | 0 | 0 | 0 | 0 | 0 | 0 |
| The period | | | | 18,600 | | |

NOTE.—Values are rated as good.

## WILLOW CREEK NEAR DELL, OREG.

This station was established May 12, 1904, and was discontinued July 16, 1906, on account of unfavorable conditions. It is located at a bridge at Cole's ranch near Dell, Oreg., 28 miles above Vale. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 143, where are given also references to publications that contain data for previous years.

*Discharge measurements of Willow Creek near Dell, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 5[a] | R. S. Hall | 8.7 | 6.1 | 2.09 | 10 |
| March 27 | do | 63 | 173 | 5.80 | 371 |
| March 27 | do | 62 | 132 | 5.00 | 261 |
| March 28 | do | 54 | 91 | 4.53 | 175 |
| April 25 | do | 45 | 57 | 4.17 | 108 |
| June 15 | do | 46 | 24 | 3.11 | 36 |

[a] Measured by wading.

*Daily gage height, in feet, of Willow Creek near Dell, Oreg., for 1906.*

| Day. | Feb. | Mar. | Apr. | May. | June. | July. | Day. | Feb. | Mar. | Apr. | May. | June. | July. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 2.2 | 6.75 | 3.4 | 3.4 | 2.7 | 17 | ..... | 3.0 | 4.5 | 3.0 | 3.1 | 2.5 |
| 2 | ..... | 2.2 | 6.5 | 3.4 | 3.6 | 2.7 | 18 | ..... | 3.1 | 4.4 | 2.6 | 3.0 | 2.5 |
| 3 | ..... | 2.3 | 5.75 | 3.2 | 4.0 | 2.75 | 19 | ..... | 2.9 | 4.4 | 2.75 | 3.0 | ..... |
| 4 | ..... | 2.2 | 5.9 | 3.3 | 4.0 | 2.5 | 20 | ..... | 3.1 | 4.4 | 2.6 | 3.0 | ..... |
| 5 | ..... | 2.1 | 6.4 | 3.1 | 3.7 | 2.6 | 21 | 2.1 | 3.0 | 4.5 | 2.9 | 2.9 | ..... |
| 6 | ..... | 2.1 | 6.1 | 3.0 | 3.7 | 2.6 | 22 | 2.15 | 2.6 | 4.6 | 3.0 | 2.9 | ..... |
| 7 | ..... | 2.2 | 6.0 | 2.9 | 3.6 | 2.6 | 23 | 2.2 | 3.1 | 4.4 | 3.6 | 2.8 | ..... |
| 8 | ..... | 2.6 | 6.1 | 3.1 | 3.5 | 2.5 | 24 | 2.2 | 5.8 | 4.5 | 3.7 | 2.6 | ..... |
| 9 | ..... | 2.8 | 6.0 | 3.0 | 3.6 | 2.6 | 25 | 2.2 | 5.6 | 4.5 | 4.0 | 2.5 | ..... |
| 10 | ..... | 2.7 | 5.9 | 3.2 | 3.6 | 2.5 | 26 | 2.1 | 5.2 | 4.0 | 4.1 | 3.1 | ..... |
| 11 | ..... | 2.5 | 5.6 | 4.0 | 3.7 | 2.6 | 27 | 2.2 | 6.15 | 4.2 | 4.0 | 2.8 | ..... |
| 12 | ..... | 2.6 | 5.4 | 4.2 | 3.5 | 2.6 | 28 | 2.1 | 5.6 | 4.0 | 4.1 | 2.8 | ..... |
| 13 | ..... | 2.4 | 5.5 | 4.2 | 3.4 | 2.6 | 29 | ..... | 6.0 | 3.6 | 4.0 | 2.75 | ..... |
| 14 | ..... | 2.1 | 5.4 | 4.2 | 3.3 | 2.5 | 30 | ..... | 5.5 | 3.5 | 3.4 | 2.8 | ..... |
| 15 | ..... | 2.4 | 5.1 | 3.0 | 3.2 | 2.6 | 31 | ..... | 6.8 | ..... | 3.7 | ..... | ..... |
| 16 | ..... | 3.0 | 4.6 | 3.0 | 3.15 | 2.5 | | | | | | | |

*Rating table for Willow Creek near Dell, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.10 | 7 | 2.90 | 32 | 3.70 | 79 | 4.50 | 156 | 5.60 | 345 |
| 2.20 | 9 | 3.00 | 37 | 3.80 | 87 | 4.60 | 168 | 5.80 | 395 |
| 2.30 | 11 | 3.10 | 42 | 3.90 | 95 | 4.70 | 181 | 6.00 | 445 |
| 2.40 | 14 | 3.20 | 47 | 4.00 | 104 | 4.80 | 195 | 6.20 | 500 |
| 2.50 | 17 | 3.30 | 53 | 4.10 | 113 | 4.90 | 210 | 6.40 | 560 |
| 2.60 | 20 | 3.40 | 59 | 4.20 | 123 | 5.00 | 225 | 6.60 | 620 |
| 2.70 | 24 | 3.50 | 65 | 4.30 | 133 | 5.20 | 260 | 6.80 | 680 |
| 2.80 | 28 | 3.60 | 72 | 4.40 | 144 | 5.40 | 300 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 6 discharge measurements made during 1906, and is fairly well defined.

*Monthly discharge of Willow Creek near Dell, Oreg., for 1906.*

[Drainage area, 455 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| February 21–28 | 9 | 7 | 8.12 | 129 | 0.018 | 0.01 |
| March | 680 | 7 | 122 | 7,500 | .268 | .31 |
| April | 665 | 65 | 279 | 16,600 | .613 | .68 |
| May | 123 | 20 | 64.5 | 3,970 | .142 | .16 |
| June | 104 | 17 | 52.0 | 3,090 | .114 | .13 |
| July 1–18 | 26 | 17 | 19.6 | 700 | .043 | .03 |
| The period | ..... | ..... | ..... | 32,000 | ..... | ..... |

NOTE.—Values are rated as fair.

## POWDER RIVER AT SALISBURY, OREG.[a]

This station was established December 20, 1903. It is located 10 miles above Baker City, Oreg., and one-fourth mile below Salisbury, a station on the Sumpter Valley Railway. The station is above all important diversions and above the point where the river enters the valley which surrounds Baker City. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 148, where are given also references to publications that contain data for previous years.

*Discharge measurements of Powder River at Salisbury, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 9[a] | R. S. Hall | 27 | 24 | 2.25 | 45 |
| March 9[a] | do | 24 | 23 | 2.28 | 48 |
| April 14 | do | 40 | 88 | 3.80 | 368 |
| April 23 | do | 43 | 119 | 4.55 | 655 |
| May 14 | do | 40 | 79 | 3.60 | 321 |
| June 12 | do | 41 | 74 | 3.42 | 297 |
| November 30[b] | Stevens and McGlashan | 35 | 32 | 2.38 | 25 |

[a] Slush ice running.
[b] Ice measurement; 15 feet of open channel.

*Daily gage height, in feet, of Powder River at Salisbury, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.1 | 2.05 | 2.15 | 4.05 | 4.15 | 3.35 | 2.65 | 2.0 | 1.8 | 1.8 | 1.95 | 2.5 |
| 2 | 2.1 | 2.05 | 2.15 | 4.2 | 4.05 | 3.25 | 2.55 | 2.05 | 1.75 | 1.75 | 2.0 | 2.35 |
| 3 | 2.05 | 2.1 | 2.15 | 3.55 | 4.15 | 3.3 | 2.6 | 1.85 | 1.75 | 1.7 | 2.1 | 2.35 |
| 4 | 2.05 | 2.1 | 2.15 | 3.65 | 4.25 | 3.4 | 2.45 | 1.85 | 1.75 | 1.75 | 2.15 | 2.45 |
| 5 | 2.05 | 2.1 | 2.15 | 4.3 | 4.15 | 3.5 | 2.4 | 1.8 | 1.75 | 1.8 | 2.25 | 2.45 |
| 6 | 2.05 | 2.15 | 2.15 | 4.95 | 3.75 | 3.5 | 2.35 | 1.9 | 1.7 | 1.75 | 2.25 | 2.45 |
| 7 | 2.05 | 2.15 | 2.15 | 5 0 | 4.05 | 3.4 | 2.35 | 1.85 | 1.75 | 1.8 | 2.2 | 2.5 |
| 8 | 2.05 | 2.15 | 2.2 | 4.5 | 4.05 | 3.4 | 2.35 | 1.9 | 1.75 | 1.8 | 2.3 | 2.5 |
| 9 | 2.1 | 2.2 | 2.2 | 4.25 | 4.05 | 3.3 | 2.3 | 1.85 | 1.8 | 1.7 | 2.25 | 2.45 |
| 10 | 2.1 | 2.2 | 2.25 | 4.1 | 3.85 | 3.4 | 2.25 | 1.8 | 1.7 | 1.75 | 2.2 | 2.45 |
| 11 | 2.1 | 2.2 | 2.15 | 4.2 | 3.7 | 3.35 | 2.25 | 1.85 | 1.8 | 1.75 | 2.25 | 2.55 |
| 12 | 2.1 | 2.2 | 2.1 | 3.95 | 3.7 | 3.45 | 2.25 | 1.85 | 1.85 | 1.75 | 2.35 | 2.45 |
| 13 | 2.1 | 2.2 | 2.1 | 3.9 | 3.65 | 3.4 | 2.3 | 1.75 | 1.75 | 1.8 | 2.35 | 2.45 |
| 14 | 2.05 | 2.25 | 2.2 | 4.05 | 3.55 | 3.35 | 2.25 | 1.7 | 1.8 | 1.75 | 2.25 | 2.55 |
| 15 | 2.05 | 2.25 | 2.25 | 4.15 | 3.35 | 3.25 | 2.3 | 1.75 | 1.75 | 1.75 | 2.15 | 2.5 |
| 16 | 2.05 | 2.3 | 2.25 | 4.25 | 3.4 | 3.35 | 2.25 | 1.7 | 1.75 | 1.85 | 2.05 | 2.65 |
| 17 | 2.0 | 2.35 | 2.2 | 4.05 | 3.15 | 3.35 | 2.2 | 1.65 | 1.75 | 1.85 | 2.05 | 2.65 |
| 18 | 2.0 | 2.35 | 2.25 | 4.15 | 3.05 | 3.25 | 2.1 | 1.65 | 1.75 | 1.8 | 2.05 | 2.65 |
| 19 | 2.1 | 2.35 | 2.35 | 3.95 | 3.05 | 3.25 | 2.1 | 1.65 | 1.75 | 1.7 | 1.95 | 2.45 |
| 20 | 2.15 | 2.4 | 2.45 | 4.05 | 3.15 | 3.05 | 2.05 | 1.75 | 1.75 | 1.8 | 2.10 | 2.3 |
| 21 | 2.15 | 2.45 | 2.4 | 4.05 | 3.15 | 3.15 | 2.1 | 1.8 | 1.7 | 1.8 | 2.15 | 2 35 |
| 22 | 2.15 | 2.45 | 2.45 | 4.7 | 3.15 | 3.1 | 2.05 | 1.75 | 1.75 | 1.8 | 2.25 | 2.45 |
| 23 | 2.1 | 2.45 | 2.45 | 4.55 | 3.15 | 3.05 | 2.1 | 1.85 | 1.75 | 1.8 | 2.3 | 2.45 |
| 24 | 2.1 | 2.4 | 2.65 | 4.45 | 3.05 | 2.95 | 2.05 | 1.85 | 1.75 | 1.9 | 2.4 | 2.5 |
| 25 | 2.1 | 2.25 | 3.0 | 4.25 | 3.05 | 3.1 | 2.0 | 1.75 | 1.7 | 1.95 | 2.3 | 2.6 |
| 26 | 2.1 | 2.2 | 3.15 | 4.1 | 3.15 | 3.15 | 2.05 | 1.75 | 1.75 | 1.95 | 2.3 | 2.65 |
| 27 | 2.1 | 2.1 | 3.5 | 3.6 | 3.1 | 3.05 | 2.05 | 1.7 | 1.75 | 1.95 | 2.3 | 2.65 |
| 28 | 2.15 | 2.15 | 3.5 | 3.55 | 3.25 | 2.95 | 2.05 | 1.8 | 1.8 | 1.9 | 2 25 | 2.55 |
| 29 | 2.15 | ..... | 3.6 | 3.45 | 3.15 | 2.85 | 2.0 | 1.75 | 1.8 | 1.9 | 2.3 | 2.45 |
| 30 | 2.1 | ..... | 4.2 | 3.95 | 3.15 | 2.7 | 1.9 | 1.75 | 1.7 | 1.85 | 2.4 | 2.45 |
| 31 | 2.1 | ..... | 4.55 | ..... | 3.25 | ..... | 1.9 | 1.75 | ..... | 1.85 | ..... | 2.4 |

NOTE.—The river was frozen January 1 to about February 24 and November 19 to December 31. The gage heights of this stream vary somewhat during the day on account of placer mining upstream.

[a] Formerly known as Powder River near Baker City.

*Rating tables for Powder River at Salisbury, Oreg.*

OPEN-CHANNEL CONDITIONS, 1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.60 | 4 | 2.20 | 38 | 2.80 | 120 | 3.40 | 267 | 4.00 | 469 |
| 1.70 | 7 | 2.30 | 48 | 2.90 | 140 | 3.50 | 299 | 4.20 | 537 |
| 1.80 | 11 | 2.40 | 60 | 3.00 | 161 | 3.60 | 333 | 4.40 | 605 |
| 1.90 | 16 | 2.50 | 72 | 3.10 | 184 | 3.70 | 367 | 4.60 | 673 |
| 2.00 | 22 | 2.60 | 86 | 3.20 | 209 | 3.80 | 401 | 4.80 | 741 |
| 2.10 | 30 | 2.70 | 102 | 3.30 | 237 | 3.90 | 435 | 5.00 | 810 |

[a] This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1905, and is well defined between gage heights 1.7 feet and 4.6 feet.

ICE CONDITIONS, 1906.[b]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.95 | 9 | 2.10 | 15 | 2.30 | 23 | 2.50 | 32 | 2.70 | 42 |
| 2.00 | 11 | 2.20 | 19 | 2.40 | 27 | 2.60 | 37 | | |

[b] This table is applicable only for ice conditions. It is based on 3 discharge measurements made at times of ice obstruction during 1904–1906, and is not well defined.

*Monthly discharge of Powder River at Salisbury, Oreg., for 1906.*

[Drainage area, 275 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 17 | 11 | 14.5 | 892 | 0.053 | 0.06 |
| February | 43 | 13 | 23.1 | 1,280 | .084 | .09 |
| March | 656 | 30 | 114 | 7,010 | .415 | .48 |
| April | 810 | 283 | 513 | 30,500 | 1.87 | 2.09 |
| May | 554 | 172 | 312 | 19,200 | 1.13 | 1.30 |
| June | 299 | 102 | 222 | 13,200 | .807 | .90 |
| July | 94 | 16 | 41.8 | 2,570 | .152 | .18 |
| August | 26 | 5 | 11.1 | 682 | .040 | .05 |
| September | 13 | 7 | 9.2 | 547 | .033 | .04 |
| October | 19 | 7 | 11.6 | 713 | .042 | .05 |
| November | 54 | 9 | 30.5 | 1,810 | .111 | .12 |
| December | 40 | 23 | 31.7 | 1,950 | .115 | .13 |
| The year | 810 | 5 | 111 | 80,400 | .404 | 5.49 |

NOTE.—Values are rated as follows: January, February, November, and December, fair; March to October, good.

## GRANDE RONDE RIVER AT HILGARD, OREG.

This station was established November 6, 1903. It is located at the county highway bridge one-half mile below the Oregon Railroad and Navigation Company station at Hilgard, Oreg. It is just below the mouth of Five Points Creek, which is the first important tributary above Grande Ronde Valley. There are two dams about 20 miles upstream, used to flood the river during the log-driving season. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 150, where are given also references to publications that contain data for previous years.

Gage heights observed during 1906 are of no value as an index of discharge, on account of obstruction and backwater from log jams.

*Discharge measurements of Grande Ronde River at Hilgard, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 10 | R. S. Hall | 108.5 | 371 | 5.18 | 745 |
| April 3 | do | 102 | 378 | 4.88 | 1,140 |
| May 16[a] | do | 70 | 370 | 6.74 | 657 |
| June 22 | do | 70 | 242 | 3.74 | 238 |
| December 4[b] | Stevens and McGlashan | 70 | 181 | 3.02 | 66 |

[a] Backwater from log jam. [b] Ice measurements.

## GRANDE RONDE RIVER AT ELGIN, OREG.

This station was established November 20, 1903. It is located at the lower end of the Grande Ronde Valley at the county bridge on the road from Elgin to Wallowa, Oreg., and is one-fourth mile east of the railroad station. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 153, where are given also references to publications that contain data for previous years.

*Discharge measurements of Grande Ronde River at Elgin, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 18 | R. S. Hall | 95 | 367 | 3.34 | 1,030 |
| June 29 | do | 94 | 334 | 2.93 | 666 |
| December 10[a] | Stevens and McGlashan | 90 | 310 | 2.20 | 290 |

[a] Narrow strip of ice on each bank.

*Daily gage height, in feet, of Grande Ronde River at Elgin, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.9 | 2.0 | 2.55 | 5.45 | 4.2 | 5.75 | 3.0 | 1.55 | 1.5 | 1.7 | ..... | 2.05 |
| 2 | 1.85 | 1.9 | 2.5 | 5.4 | 4.2 | 5.75 | 2.6 | 1.55 | 1.5 | 1.7 | 1.85 | 2.05 |
| 3 | 1.9 | 1.95 | 2.45 | 5.2 | 4.2 | 5.8 | 2.6 | 1.5 | 1.5 | 1.7 | 1.85 | 2.0 |
| 4 | 1.95 | 1.95 | 2.45 | 5.0 | 4.15 | 5.75 | 2.6 | 1.55 | 1.5 | 1.7 | 1.9 | 2.0 |
| 5 | 1.85 | 1.9 | 2.45 | 4.8 | 4.0 | 5.7 | 2.5 | 1.55 | 1.5 | 1.7 | 2.0 | 2.0 |
| 6 | 1.9 | 1.95 | 2.4 | 4.7 | 3.95 | 5.5 | 2.5 | 1.55 | 1.5 | 1.7 | 2.0 | 2.05 |
| 7 | 1.9 | 2.0 | 2.45 | 4.75 | 3.95 | 5.5 | 2.45 | 1.55 | ..... | 1.7 | 2.0 | 2.1 |
| 8 | 1.9 | 1.95 | 2.9 | 4.9 | 3.8 | 5.45 | 2.35 | 1.55 | 1.5 | 1.7 | 2.05 | 2.2 |
| 9 | 1.85 | 1.9 | 3.1 | 5.0 | 3.75 | 5.3 | 2.5 | 1.5 | 1.5 | 1.7 | 2.05 | 2.2 |
| 10 | 1.9 | 1.9 | 3.45 | 5.1 | 3.7 | 5.1 | 2.35 | 1.5 | 1.5 | 1.7 | 2.05 | 2.25 |
| 11 | 1.9 | ..... | 3.5 | 5.0 | 3.75 | 4.9 | ..... | 1.5 | 1.5 | 1.7 | ..... | 2.3 |
| 12 | 2.0 | 1.9 | 3.25 | 4.85 | 3.7 | 4.3 | 2.1 | 1.55 | 1.55 | 1.7 | ..... | ..... |
| 13 | 1.9 | 1.9 | 2.9 | 4.7 | 3.7 | 4.5 | 2.0 | 1.5 | 1.6 | 1.75 | 2.05 | 2.3 |
| 14 | 1.85 | 1.95 | 2.65 | 4.5 | 3.6 | 4.3 | 2.0 | 1.5 | 1.65 | 1.75 | 2.2 | 2.25 |
| 15 | 1.85 | 2.0 | 2.5 | 4.7 | 3.6 | 4.2 | 1.9 | 1.5 | 1.7 | ..... | 2.5 | 2.1 |
| 16 | 2.0 | 2.05 | 2.6 | 4.5 | 3.6 | 4.2 | 1.9 | 1.5 | 1.7 | 1.75 | 2.6 | 2.1 |
| 17 | 2.0 | 2.2 | 2.5 | 4.5 | 3.6 | 4.2 | 1.85 | 1.5 | 1.75 | 1.8 | 2.6 | ..... |
| 18 | 2.0 | 2.65 | 2.45 | 4.5 | 3.45 | 4.05 | 1.85 | 1.5 | 1.8 | 1.8 | 2.5 | 2.15 |
| 19 | 1.95 | 2.6 | 2.45 | 4.5 | 3.2 | 3.85 | 1.8 | 1.5 | 1.8 | 1.8 | 2.35 | 2.25 |
| 20 | 1.95 | 2.85 | 2.45 | 4.5 | 3.15 | 3.75 | ..... | 1.5 | 1.8 | 1 75 | 2.3 | 2.7 |
| 21 | 1.9 | 2.8 | 2.4 | 4.5 | 3.0 | 3.6 | 1.7 | 1.5 | 1.8 | 1.8 | 2.1 | 3.1 |
| 22 | 1.85 | 2.8 | 2.5 | 4.7 | 3.0 | 3.5 | 1.65 | 1.5 | 1.75 | 1.8 | 2.0 | 3.1 |
| 23 | 1.95 | 2 75 | 2.8 | 4.9 | 3.0 | 3.3 | 1.65 | 1.5 | 1.75 | 1.8 | 2.2 | 3.3 |
| 24 | 2.0 | 2.65 | 3.8 | 4.8 | 3.0 | 3.25 | 1.65 | 1.5 | 1.7 | 1.8 | 2.1 | 3.45 |
| 25 | 2.1 | 2.65 | 4.2 | 4.75 | 3.0 | 3.2 | 1.65 | 1.5 | 1.7 | 1.8 | 2.1 | 3.9 |
| 26 | ..... | 2.6 | 4.5 | 4.6 | 3.0 | 3.1 | ..... | 1.5 | 1.7 | 1.8 | 2.1 | 4.3 |
| 27 | 2.2 | 2.7 | 4.8 | 4.5 | 2.9 | 3.0 | 1.65 | 1.5 | 1.7 | ..... | 2.1 | 4.4 |
| 28 | 2.1 | 2.65 | 4.9 | ..... | 2.9 | 3.1 | 1.65 | 1.5 | 1.7 | 1.8 | 2.1 | 4.35 |
| 29 | 2.0 | ..... | ..... | 4.35 | 3.3 | 3.0 | 1.6 | 1.5 | 1.75 | 1.8 | 1.95 | 4.0 |
| 30 | 2.0 | ..... | 5.1 | 4.1 | 4.45 | 2.9 | 1.6 | 1.5 | 1.75 | 1.8 | 2.0 | 3.85 |
| 31 | 1.95 | ..... | 5.45 | ..... | 4.7 | ..... | 1.6 | 1.5 | ..... | 1.8 | ..... | 3.7 |

NOTE.—There was some ice obstruction during November and December.

*Rating table for Grande Ronde River at Elgin, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.50 | 45 | 2.20 | 260 | 2.90 | 640 | 3.60 | 1,340 | 4.60 | 3,020 |
| 1.60 | 67 | 2.30 | 305 | 3.00 | 710 | 3.70 | 1,480 | 4.80 | 3,380 |
| 1.70 | 92 | 2.40 | 350 | 3.10 | 790 | 3.80 | 1,630 | 5.00 | 3,740 |
| 1.80 | 120 | 2.50 | 400 | 3.20 | 880 | 3.90 | 1,790 | 5.20 | 4,100 |
| 1.90 | 150 | 2.60 | 455 | 3.30 | 980 | 4.00 | 1,960 | 5.40 | 4,460 |
| 2.00 | 185 | 2.70 | 515 | 3.40 | 1,090 | 4.20 | 2,300 | 5.60 | 4,820 |
| 2.10 | 220 | 2.80 | 575 | 3.50 | 1,210 | 4.40 | 2,660 | 5.80 | 5,200 |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904–1906 and is well defined below gage height 3.5 feet.

*Monthly discharge of Grande Ronde River at Elgin, Oreg., for 1906.*

[Drainage area, 1,350 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 260 | 135 | 172 | 10,600 | 0.127 | 0.15 |
| February | 608 | 150 | 293 | 16,300 | .217 | .23 |
| March | 4,550 | 350 | 1,230 | 75,600 | .911 | 1.05 |
| April | 4,550 | 2,130 | 3,270 | 195,000 | 2.42 | 2.70 |
| May | 3,200 | 640 | 1,440 | 88,500 | 1.07 | 1.23 |
| June | 5,200 | 640 | 2,670 | 159,000 | 1.98 | 2.21 |
| July | 710 | 67 | 220 | 13,500 | .163 | .19 |
| August | 56 | 45 | 47.8 | 2,940 | .035 | .04 |
| September | 120 | 45 | 78.4 | 4,670 | .058 | .06 |
| October | 120 | 92 | 107 | 6,580 | .079 | .09 |
| November | 455 | 128 | 235 | 14,000 | .174 | .19 |
| December | 2,660 | 185 | 756 | 46,500 | .560 | .65 |
| The year | 5,200 | 45 | 877 | 603,000 | .650 | 8.79 |

NOTE.—Discharges have been interpolated for days when the gage was not read. November and December have been applied as for open channel. Values are rated as follows: January, February, July, and October to December, fair; March to June, good; August and September, approximate.

## GRANDE RONDE RIVER AT ZINDEL, WASH.

This station was established June 30, 1904. It is located at Zindel Ferry, 2 miles above the mouth of the river and 1½ miles below Joseph Creek. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 155, where are given also references to publications that contain data for previous years.

The following measurement was made by floats December 22, 1906:

Width, 224 feet; area, 1,310 square feet; gage height, 5.60 feet; discharge, 8,400 second-feet.

*Daily gage height, in feet, of Grande Ronde River at Zindel, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.2 | 2.45 | 3.5 | 6.4 | 5.1 | 6.0 | 3.9 | 2.2 | 2.1 | 2.1 | 2.35 | 3.0 |
| 2 | 2.2 | 2.3 | 3.3 | 6.0 | 5.1 | 5.8 | 3.9 | 2.2 | 2.1 | 2.1 | 2.35 | 3.0 |
| 3 | 2.2 | 2.25 | 3.3 | 5.8 | 5.0 | 5.7 | 3.8 | 2.2 | 2.1 | 2.1 | 2.3 | 3.0 |
| 4 | 2.3 | 2.3 | 3.3 | 5.5 | 5.1 | 5.9 | 3.8 | 2.2 | 2.2 | 2.2 | 2.3 | 3.0 |
| 5 | 2.3 | 2.35 | 3.5 | 5.5 | 5.0 | 5.8 | 3.8 | 2.2 | 2.2 | 2.2 | 2.3 | 3.0 |
| 6 | 2.3 | 2.35 | 3.5 | 5.7 | 4.8 | 5.8 | 3.8 | 2.2 | 2.2 | 2.2 | 2.3 | 2.9 |
| 7 | 2.3 | 2.35 | 3.5 | 5.9 | 4.7 | 5.8 | 3.8 | 2.2 | 2.2 | 2.2 | 2.6 | 2.9 |
| 8 | 2.3 | 2.3 | 3.5 | 5.9 | 4.7 | 5.7 | 3.75 | 2.2 | 2.2 | 2.2 | 3.35 | 3.0 |
| 9 | 2.3 | 2.3 | 3.9 | 6.0 | 4.7 | 5.7 | 3.6 | 2.2 | 2.2 | 2.2 | 3.3 | 3.1 |
| 10 | 2.3 | 2.25 | 4.2 | 5.9 | 4.9 | 5.5 | 3.6 | 2.2 | 2.2 | 2.2 | 3.1 | 3.2 |
| 11 | 2.3 | 2.25 | 4.1 | 5.8 | 5.1 | 5.5 | 3.6 | 2.2 | 2.1 | 2.2 | 3.0 | 3.2 |
| 12 | 2.3 | 2.3 | 3.9 | 5.2 | 5.0 | 5.7 | 3.55 | 2.2 | 2.1 | 2.2 | 3.1 | 3.4 |
| 13 | 2.35 | 2.3 | 3.7 | 5.2 | 4.8 | 5.7 | 3.5 | 2.4 | 2.2 | 2.2 | 3.4 | 3.4 |
| 14 | 2.35 | 2.3 | 3.2 | 5.1 | 4.7 | 5.2 | 3.25 | 2.2 | 2.2 | 2.2 | 6.85 | 3.1 |
| 15 | 2.2 | 2.3 | 3.2 | 5.2 | 4.5 | 4.9 | 3.0 | 2.2 | 2.2 | 2.2 | 6.85 | 3.1 |
| 16 | 2.2 | 2.5 | 3.2 | 5.3 | 4.2 | 5.2 | 3.0 | 2.2 | 2.2 | 2.25 | 5.8 | 3.1 |
| 17 | 2.25 | 2.5 | 2.8 | 5.0 | 4.2 | 5.0 | 3.0 | 2.2 | 2.1 | 2.25 | 5.1 | 3.0 |
| 18 | 2.25 | 2.8 | 3.0 | 5.3 | 4.0 | 4.8 | 2.9 | 2.2 | 2.1 | 2.25 | 4.5 | 3.0 |
| 19 | 2.3 | 3.9 | 2.9 | 5.3 | 4.0 | 4.6 | 2.8 | 2.2 | 2.15 | 2.25 | 4.1 | 3.1 |
| 20 | 2.3 | 3.9 | 2.9 | 5.3 | 4.0 | 4.4 | 2.7 | 2.2 | 2.15 | 2.25 | 3.9 | 3.3 |
| 21 | 2.3 | 3.55 | 2.9 | 5.5 | 4.0 | 4.3 | 2.7 | 2.05 | 2.15 | 2.25 | 3.9 | 5.65 |
| 22 | 2.3 | 3.7 | 3.1 | 6.0 | 4.0 | 4.2 | 2.6 | 2.0 | 2.15 | 2.25 | 3.6 | 5.6 |
| 23 | 2.4 | 3.8 | 3.1 | 6.0 | 3.9 | 4.1 | 2.55 | 2.0 | 2.15 | 2.25 | 3.5 | 5.1 |
| 24 | 2.4 | 3.8 | 3.4 | 6.0 | 3.9 | 4.0 | 2.55 | 2.2 | 2.15 | 2.25 | 3.3 | 5.1 |
| 25 | 2.5 | 3.6 | 4.9 | 5.6 | 3.9 | 3.9 | 2.4 | 2.2 | 2.1 | 2.25 | 3.3 | 4.9 |
| 26 | 2.6 | 3.45 | 5.2 | 5.6 | 3.8 | 3.9 | 2.4 | 2.2 | 2.1 | 2.25 | 3.1 | 5.8 |
| 27 | 2.55 | 3.7 | 5.6 | 5.6 | 3.8 | 3.8 | 2.4 | 2.2 | 2.1 | 2.3 | 3.1 | 5.9 |
| 28 | 2.4 | 3.5 | 5.7 | 5.4 | 3.8 | 3.8 | 2.3 | 2.2 | 2.1 | 2.45 | 3.0 | 5.7 |
| 29 | 2.4 | ..... | 5.8 | 5.0 | 4.1 | 3.8 | 2.3 | 2.1 | 2.1 | 2.45 | 3.0 | 5.4 |
| 30 | 2.4 | ..... | 5.8 | 5.1 | 4.8 | 3.8 | 2.3 | 2.1 | 2.1 | 2.4 | 3.0 | 5.3 |
| 31 | 2.4 | ..... | 6.1 | ..... | 5.6 | ..... | 2.2 | 2.1 | ..... | 2.4 | ..... | 5.0 |

## CATHERINE CREEK NEAR UNION, OREG.

This station was established May 15, 1906. It is located in the canyon at the head of a fertile valley 6 miles above Union.

Discharge measurements are made from a highway bridge just below Robbins's sawmill, where there is a dam that affects the flow somewhat.

The gage is read by H. D. Drake, who is paid by the citizens of Union. It is a vertical staff attached to the downstream side of the bridge. The bench mark is the head of a spike driven into the top of the downstream end of log-tying at the end of the bridge; elevation, 7.67 feet above the datum of the gage.

*Discharge measurements of Catherine Creek near Union, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 29 | R. S. Hall | 38 | 68 | 3.20 | 335 |
| May 15 | do | 38 | 68 | 3.30 | 378 |
| June 24 | do | 37.5 | 61 | 3.10 | 276 |
| December 1[a] | Stevens and McGlashan | 39 | 51 | 2.80 | 54 |

[a] Channel obstructed by anchor ice.

*Daily gage height, in feet, of Catherine Creek near Union, Oreg., for 1906.*

| Day. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| 1 | | 3.5 | 2.9 | 2.1 | 2.1 | 2.0 | 2.0 | 2.5 |
| 2 | | 3.7 | 2.8 | 2.1 | 2.1 | 2.0 | 2.0 | 2.6 |
| 3 | | 3.8 | 2.8 | 2.1 | 2.1 | 2.1 | 2.1 | 2.6 |
| 4 | | 4.0 | 2.8 | 2.1 | 2.0 | 2.1 | 2.1 | 2.8 |
| 5 | | 3.9 | 2.8 | 2.1 | 2.0 | 2.1 | 2.2 | 2.5 |
| 6 | | 3.8 | 2.7 | 2.1 | 2.0 | 2.0 | 2.1 | 2.3 |
| 7 | | 3.7 | 2.7 | 2.1 | 2.0 | 2.0 | 2.2 | 2.3 |
| 8 | | 3.5 | 2.7 | 2.1 | 2.0 | 2.0 | 2.2 | 2.2 |
| 9 | | 3.5 | 2.6 | 2.1 | 2.0 | 2.0 | 2.2 | 2.2 |
| 10 | | 3.5 | 2.6 | 2.1 | 2.0 | 2.0 | 2.2 | 2.2 |
| 11 | | 3.6 | 2.6 | 2.1 | 2.0 | 2.0 | 2.2 | 2.3 |
| 12 | | 3.6 | 2.5 | 2.1 | 2.0 | 2.1 | 2.2 | 2.3 |
| 13 | | 3.5 | 2.5 | 2.1 | 2.1 | 2.0 | 3.1 | 2.2 |
| 14 | | 3.4 | 2.5 | 2.1 | 2.1 | 2.0 | 3.6 | 2.2 |
| 15 | 3.3 | 3.3 | 2.4 | 2.1 | 2.1 | 2.0 | 3.0 | 2.2 |
| 16 | 3.2 | 3.3 | 2.4 | 2.1 | 2.1 | 2.0 | 2.7 | 2.2 |
| 17 | 3.1 | 3.3 | 2.4 | 2.1 | 2.1 | 2.0 | 2.6 | 2.2 |
| 18 | 3.0 | 3.3 | 2.4 | 2.1 | 2.1 | 2.0 | 2.5 | 2.2 |
| 19 | 3.0 | 3.2 | 2.4 | 2.1 | 2.0 | 2.0 | 2.7 | 2.2 |
| 20 | 3.0 | 3.1 | 2.3 | 2.1 | 2.0 | 2.0 | 2.5 | 2.3 |
| 21 | 3.0 | 3.1 | 2.3 | 2.1 | 2.0 | 2.0 | 2.5 | 2.3 |
| 22 | 3.0 | 3.1 | 2.3 | 2.1 | 2.0 | 2.0 | 2.4 | 2.4 |
| 23 | 3.0 | 3.0 | 2.3 | 2.1 | 2.0 | 2.0 | 2.3 | 2.5 |
| 24 | 3.0 | 3.0 | 2.3 | 2.1 | 2.0 | 2.0 | 2.2 | 2.6 |
| 25 | 3.0 | 3.0 | 2.3 | 2.1 | 2.0 | 2.0 | 2.3 | 2.7 |
| 26 | 3.1 | 3.0 | 2.3 | 2.1 | 2.0 | 2.1 | 2.5 | 3.0 |
| 27 | 3.1 | 3.1 | 2.2 | 2.1 | 2.0 | 2.1 | 2.5 | 3.0 |
| 28 | 3.0 | 3.0 | 2.2 | 2.1 | 2.0 | 2.0 | 2.4 | 2.8 |
| 29 | 3.2 | 2.9 | 2.2 | 2.1 | 2.0 | 2.1 | 2.4 | 2.7 |
| 30 | 3.3 | 2.8 | 2.2 | 2.1 | 2.0 | 2.0 | 2.4 | 2.7 |
| 31 | 3.4 | ..... | 2.2 | 2.1 | ..... | 2.0 | ..... | 2.6 |

NOTE.—Anchor ice formed in the bed of the stream about December 10 and remained until the end of the year.

## WALLOWA RIVER AT JOSEPH, OREG.

This station was established November 12, 1903. It is located 500 feet below the outlet of Wallowa Lake, about 1¼ miles above Joseph, Oreg. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 156, where are given also references to publications that contain data for previous years.

*Discharge measurements of Wallowa River at Joseph, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 23 | R. S. Hall | 37.5 | 64 | 2.65 | 247 |
| June 27 | do | 37.5 | 75 | 2.80 | 336 |
| December 7 | Stevens and McGlashan | 33 | 42 | 2.20 | 128 |

*Daily gage height, in feet, of Wallowa River at Joseph, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.9 | 1.9 | 2.1 | 2.0 | 2.4 | 2.6 | 2.8 | 2.9 | 2.05 | 1.8 | 1.95 | 2.3 |
| 2 | 1.9 | 1.9 | 2.1 | 2.0 | 2.4 | 2.6 | 2.85 | 2.9 | 2.0 | 1.9 | ..... | 2.3 |
| 3 | 1.9 | 1.9 | 2.05 | 1.95 | 2.4 | 2.65 | 2.9 | 2.95 | 2.0 | 1.9 | 2.0 | 2.3 |
| 4 | 1.95 | 1.9 | 2.0 | 1.95 | 2.45 | 2.6 | 3.0 | 2.9 | 2.0 | 1.9 | 2.1 | 2.3 |
| 5 | 1.95 | 1.9 | 2.0 | 1.95 | 2.5 | 2.6 | 3.0 | 2.85 | 2.0 | 1.85 | 2.05 | 2.25 |
| 6 | 1.95 | 1.9 | 2.0 | 1.95 | 2.2 | 2.6 | 3.0 | 2.8 | 2.0 | 1.9 | 2.05 | 2.2 |
| 7 | 1.95 | 1.9 | 1.95 | 1.95 | 2.3 | 2.6 | 3.0 | 2.8 | 2.0 | 1.9 | 2.1 | 2.2 |
| 8 | 1.95 | 1.9 | 2.0 | 1.95 | 2.35 | 2.6 | 3.0 | 2.75 | 2.0 | 1.9 | 2.1 | 2.2 |
| 9 | 1.95 | 1.9 | 2.0 | 2.0 | 2.4 | 2.6 | 3.1 | 2.7 | 2.0 | 1.9 | 2.1 | 2.2 |
| 10 | 1.9 | 1.9 | 2.0 | 2.0 | 2.45 | 2.7 | 3.15 | 2.6 | 2.0 | 1.9 | 2.1 | 2.2 |
| 11 | 1.9 | 1.9 | 2.0 | 2.0 | 2.5 | 2.65 | 3.15 | 2.5 | 2.0 | 1.9 | ..... | 2.2 |
| 12 | 1.9 | 1.9 | ..... | 2.0 | 2.5 | 2.6 | 3.0 | 2.5 | 2.5 | 1.9 | 2.15 | 2.2 |
| 13 | 1.9 | 1.9 | 2.0 | 2.0 | 2.4 | 2.65 | 3.0 | 2.5 | 2.5 | 1.9 | 2.2 | 2.2 |
| 14 | 1.9 | 1.9 | 2.0 | 2.0 | 2.35 | 2.7 | 3.0 | 2.5 | 2.1 | 1.9 | 2.3 | 2.2 |
| 15 | 1.9 | 1.9 | 2.0 | 2.0 | 2.3 | 2.7 | 3.0 | 2.45 | 2.1 | 1.9 | 2.5 | 2.2 |
| 16 | 2.0 | 1.9 | 1.95 | 2.0 | 2.3 | 2.65 | 3.05 | 2.4 | 2.0 | 1.9 | 2.6 | 2.2 |
| 17 | 1.95 | 1.9 | 1.95 | 2.0 | 2.4 | 2.55 | 2.95 | 2.4 | 2.0 | 1.95 | 2.6 | 2.2 |
| 18 | 1.95 | 1.9 | 1.95 | 2.0 | 2.4 | 2.6 | 2.8 | 2.35 | 2.0 | 1.95 | 2.7 | 2.15 |
| 19 | 1.95 | 1.95 | 1.9 | 2.0 | 2.4 | 2.5 | 2.8 | ..... | 2.0 | 1.95 | 2.7 | 2.1 |
| 20 | 1.95 | 1.9 | 1.9 | 2.1 | 2.4 | 2.5 | 2.85 | 2.3 | 2.0 | 1.95 | 2.65 | 2.1 |
| 21 | 1.95 | 1.95 | 1.95 | 2.15 | 2.4 | 2.6 | 2.85 | 2.3 | 2.0 | 1.95 | 2.65 | 2.2 |
| 22 | 1.9 | 1.95 | ..... | 2.2 | 2.4 | 2.6 | 2.8 | 2.25 | 2.0 | 1.95 | 2.6 | 2.2 |
| 23 | 1.95 | 1.95 | 1.95 | 2.3 | 2.6 | 2.7 | 2.75 | 2.2 | 2.0 | 1.95 | 2.6 | 2.2 |
| 24 | 1.95 | 1.95 | 1.95 | 2.3 | 2.7 | 2.7 | 2.8 | 2.25 | ..... | 1.95 | 2.55 | 2.2 |
| 25 | 1.95 | 1.95 | 1.95 | 2.3 | 2.5 | 2.7 | 2.8 | 2.2 | 2.0 | 1.95 | 2.55 | 2.15 |
| 26 | 1.95 | 1.95 | 1.95 | 2.35 | 2.7 | ..... | 2.85 | 2.15 | 1.9 | 1.9 | 2.5 | 2.1 |
| 27 | 1.95 | 2.1 | 1.95 | 2.35 | 2.8 | 2.8 | 2.9 | 2.1 | 1.8 | 1.9 | 2.45 | 2.1 |
| 28 | 1.95 | 2.1 | 1.95 | 2.4 | 2.65 | 2.85 | 3.0 | 2.1 | 1.85 | 1.95 | 2.4 | 2.15 |
| 29 | 1.9 | ..... | 1.95 | 2.4 | 2.7 | 2.85 | 2.95 | 2.1 | 1.85 | 1.95 | 2.4 | 2.2 |
| 30 | 1.9 | ..... | 1.95 | 2.4 | 2.7 | 2.85 | 2.9 | 2.1 | 1.8 | 1.9 | 2.35 | 2.15 |
| 31 | 1.9 | ..... | 2.0 | ..... | 2.6 | ..... | 2.9 | 2.1 | ..... | 1.95 | ..... | 2.15 |

NOTE.—The river was not frozen at any time during the year.

*Rating table for Wallowa River at Joseph, Oreg., for 1906.*

| Gage height. | Discharge. | Gage heignt. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.80 | 26 | 2.20 | 104 | 2.50 | 209 | 2.80 | 350 | 3.10 | 527 |
| 1.90 | 35 | 2.30 | 135 | 2.60 | 252 | 2.90 | 405 | 3.20 | 597 |
| 2.00 | 54 | | | | | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is well defined between gage heights 2.0 feet and 2.75 feet.

*Monthly discharge of Wallowa River at Joseph, Oreg., for 1906.*

[Drainage area, 47 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 54 | 35 | 40.5 | 2,490 | 0.862 | 0.99 |
| February | 77 | 35 | 40.2 | 2,230 | .855 | .89 |
| March | 77 | 35 | 50.1 | 3,080 | 1.07 | 1.23 |
| April | 170 | 44 | 81.9 | 4,870 | 1.74 | 1.94 |
| May | 350 | 104 | 201 | 12,400 | 4.28 | 4.93 |
| June | 377 | 209 | 279 | 16,600 | 5.94 | 6.63 |
| July | 561 | 324 | 426 | 26,200 | 9.06 | 10.44 |
| August | 434 | 77 | 208 | 12,800 | 4.43 | 5.11 |
| September | 209 | 26 | 62.1 | 3,700 | 1.32 | 1.47 |
| October | 44 | 26 | 38.0 | 2,340 | 0.809 | .93 |
| November | 299 | 44 | 159 | 9,460 | 3.38 | 3.77 |
| December | 135 | 77 | 103 | 6,330 | 2.19 | 2.52 |
| The year | 561 | 26 | 141 | 102,000 | 2.99 | 40.84 |

NOTE.—Values are rated as follows: January to March, September, and October, fair; remainder of year, good.

## WALLOWA RIVER NEAR WALLOWA, OREG.

This station was established November 14, 1903. It is located at the county bridge, 1½ miles below Wallowa, Oreg., and one-fourth mile below the mouth of Bear Creek. A small irrigation ditch takes water from the river about 300 feet above the bridge on the right bank. During 1906 the gage was read by L. S. Johnson and C. C. Roop. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 159, where are given also references to publications that contain data for previous years.

*Discharge measurements of Wallowa River near Wallowa, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 22 | R. S. Hall | 85 | 165 | 2.78 | 794 |
| June 26 | do | 85.5 | 198 | 3.11 | 1,120 |
| December 8 | Stevens and McGlashan | 84 | 140 | 2.22 | 528 |

*Daily gage height, in feet, of Wallowa River near Wallowa, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.7 | 1.75 | 1.9 | 2.7 | 2.8 | 3.0 | 3.0 | 1.9 | 1.9 | 1.7 | 2.0 | 2.2 |
| 2 | 1.8 | 1.7 | 1.8 | 2.5 | 2.9 | 3.1 | 3.1 | 1.9 | 1.9 | 1.7 | 1.9 | 2.2 |
| 3 | 1.8 | 1.7 | 1.9 | 2.5 | 3.0 | 3.1 | 3.2 | 1.9 | 1.9 | 1.7 | 2.0 | 2.1 |
| 4 | 1.75 | 1.65 | 1.9 | 2.4 | 3.3 | 3.3 | 3.2 | 1.9 | 1.9 | 1.7 | 2.0 | 2.1 |
| 5 | 1.75 | 1.7 | 1.9 | 2.4 | 3.0 | 3.2 | 3.3 | 1.8 | 1.8 | 1.7 | 2.1 | 2.1 |
| 6 | 1.8 | 1.6 | 1.9 | 2.5 | 3.0 | 3.1 | 3.2 | 1.8 | 1.8 | 1.7 | 2.1 | 2.1 |
| 7 | 1.7 | 1.8 | 1.9 | 2.6 | 2.9 | 3.0 | 3.2 | 1.8 | 1.8 | 1.7 | 2.1 | 2.1 |
| 8 | 1.7 | 2.0 | 1.95 | 2.6 | 2.9 | 2.9 | 3.2 | 1.8 | 1.8 | 1.7 | 2.6 | 2.2 |
| 9 | 1.8 | 2.2 | 2.0 | 2.7 | 3.0 | 2.9 | 3.1 | 1.8 | 1.9 | 1.8 | 2.6 | 2.2 |
| 10 | 1.8 | 2.0 | 2.1 | 2.7 | 3.2 | 3.0 | 3.0 | 1.7 | 1.9 | 1.8 | 2.6 | 2.1 |
| 11 | 1.75 | 2.1 | 2.0 | 2.5 | 3.4 | 3.3 | 2.8 | 1.7 | 1.9 | 1.8 | 2.7 | 2.2 |
| 12 | 1.75 | 1.8 | 1.9 | 2.5 | 3.5 | 3.8 | 2.7 | 1.8 | 1.9 | 1.8 | 2.6 | 2.2 |
| 13 | 1.8 | 1.9 | 1.8 | 2.4 | 3.1 | 3.7 | 2.7 | 1.9 | 1.8 | 1.8 | 3.5 | 2.2 |
| 14 | 1.8 | 1.8 | 1.9 | 2.4 | 3.1 | 3.4 | 2.7 | 1.9 | 2.0 | 1.8 | 4.8 | 2.1 |
| 15 | 1.7 | 1.8 | 1.9 | 2.4 | 3.0 | 3.4 | 2.6 | 1.9 | 2.0 | 1.9 | 4.7 | 2.0 |
| 16 | 1.75 | 1.8 | 1.7 | 2.6 | 2.8 | 3.8 | 2.6 | 1.8 | 1.9 | 1.9 | 3.8 | 2.0 |
| 17 | 1.8 | 1.8 | 1.7 | 2.7 | 2.7 | 3.5 | 2.5 | 1.8 | 1.9 | 2.0 | 3.3 | 2.0 |
| 18 | 1.8 | 1.8 | 1.8 | 2.7 | 2.6 | 3.2 | 2.4 | 1.8 | 1.9 | 1.9 | 3.1 | 2.0 |
| 19 | 1.8 | 2.0 | 1.9 | 2.6 | 2.5 | 3.2 | 2.4 | 1.8 | 1.9 | 1.9 | 2.9 | 2.1 |
| 20 | 1.8 | 1.9 | 1.8 | 2.7 | 2.6 | 3.2 | 2.4 | 1.8 | 1.9 | 1.9 | 2.9 | 2.3 |
| 21 | 1.8 | 2.0 | 1.9 | 2.9 | 2.6 | 3.2 | 2.4 | 1.8 | 1.8 | 1.9 | 2.8 | 2.3 |
| 22 | 1.8 | 2.0 | 1.9 | 3.1 | 2.8 | 3.1 | 2.1 | 1.8 | 1.8 | 1.9 | 2.7 | 2.3 |
| 23 | 1.8 | 2.0 | 2.0 | 3.2 | 2.7 | 3.2 | 2.1 | 1.8 | 1.8 | 1.9 | 2.6 | 2.3 |
| 24 | 1.8 | 1.9 | 2.2 | 3.0 | 2.7 | 3.1 | 2.0 | 1.8 | 1.8 | 1.9 | 2.5 | 2.3 |
| 25 | 1.8 | 1.9 | 2.4 | 2.9 | 2.7 | 3.1 | 2.0 | 1.9 | 1.8 | 1.9 | 2.5 | 2.4 |
| 26 | 1.8 | 1.9 | 2.4 | 2.7 | 2.9 | 3.2 | 1.9 | 1.8 | 1.8 | 1.9 | 2.4 | 2.6 |
| 27 | 1.7 | 1.9 | 2.6 | 2.8 | 2.9 | 3.4 | 1.9 | 1.8 | 1.8 | 1.9 | 2.3 | 2.5 |
| 28 | 1.75 | 1.9 | 2.6 | 2.8 | 2.9 | 3.3 | 1.9 | 1.8 | 1.8 | 2.1 | 2.3 | 2.5 |
| 29 | 1.75 | ..... | 2.5 | 2.8 | 2.9 | 3.0 | 1.9 | 1.8 | 1.8 | 2.1 | 2.3 | 2.5 |
| 30 | 1.75 | ..... | 2.7 | 2.8 | 3.0 | 2.9 | 1.9 | 1.9 | ..... | 2.0 | 2.3 | 2.4 |
| 31 | 1.75 | ..... | 2.7 | ..... | 3.0 | ..... | 1.9 | 1.9 | ..... | 2.0 | ..... | 2.3 |

*Rating tables for Wallowa River near Wallowa, Oreg.*

JANUARY 1 TO NOVEMBER 14, 1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.50 | 140 | 2.10 | 375 | 2.70 | 710 | 3.30 | 1,290 | 3.90 | 1,950 |
| 1.60 | 170 | 2.20 | 425 | 2.80 | 790 | 3.40 | 1,400 | 4.00 | 2,070 |
| 1.70 | 205 | 2.30 | 475 | 2.90 | 880 | 3.50 | 1,510 | 4.20 | 2,310 |
| 1.80 | 245 | 2.40 | 525 | 3.00 | 980 | 3.60 | 1,620 | 4.40 | 2,570 |
| 1.90 | 285 | 2.50 | 580 | 3.10 | 1,080 | 3.70 | 1,730 | 4.60 | 2,830 |
| 2.00 | 330 | 2.60 | 640 | 3.20 | 1,180 | 3.80 | 1,840 | 4.80 | 3,100 |

[a] This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6, and is well defined between gage heights 1.7 feet and 3.1 feet.

NOVEMBER 15 TO DECEMBER 31, 1906.[b]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.50 | 210 | 2.10 | 460 | 2.70 | 830 | 3.30 | 1,330 | 3.90 | 1,950 |
| 1.60 | 245 | 2.20 | 515 | 2.80 | 900 | 3.40 | 1,420 | 4.00 | 2,070 |
| 1.70 | 285 | 2.30 | 570 | 2.90 | 980 | 3.50 | 1,520 | 4.20 | 2,310 |
| 1.80 | 325 | 2.40 | 630 | 3.00 | 1,060 | 3.60 | 1,620 | 4.40 | 2,570 |
| 1.90 | 365 | 2.50 | 690 | 3.10 | 1,150 | 3.70 | 1,730 | 4.60 | 2,830 |
| 2.00 | 410 | 2.60 | 760 | 3.20 | 1,240 | 3.80 | 1,840 | | |

[b] This table is applicable only for open-channel conditions. It is based on one discharge measurement made during 1906 and the form of previous curves and is not well defined.

*Monthly discharge of Wallowa River near Wallowa, Oreg., for 1906.*

[Drainage area, 510 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 245 | 205 | 233 | 14,300 | 0.457 | 0.53 |
| February | 425 | 170 | 275 | 15,300 | .539 | .56 |
| March | 710 | 205 | 363 | 22,300 | .712 | .82 |
| April | 1,180 | 525 | 707 | 42,100 | 1.39 | 1.55 |
| May | 1,510 | 580 | 912 | 56,100 | 1.79 | 2.06 |
| June | 1,840 | 880 | 1,210 | 72,000 | 2.37 | 2.64 |
| July | 1,290 | 285 | 687 | 42,200 | 1.35 | 1.56 |
| August | 285 | 205 | 255 | 15,700 | .500 | 0.58 |
| September | 330 | 225 | 267 | 15,900 | .524 | 0.58 |
| October | 375 | 205 | 267 | 16,400 | .524 | 0.60 |
| November | 3,100 | 285 | 877 | 52,200 | 1.72 | 1.92 |
| December | 760 | 410 | 530 | 32,600 | 1.04 | 1.20 |
| The year | 3,100 | 170 | 549 | 397,000 | 1.08 | 14.60 |

NOTE.—Values are rated as good.

## WALLOWA RIVER NEAR ELGIN, OREG.

This station was established November 18, 1903. It is located at the county highway bridge just below the mouth of Minam River, 12 miles from Elgin, Oreg. The station is in Wallowa Canyon about 9 miles below the lower end of Wallowa Valley. The gage was read during 1906 by Tillie Ransom. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 161, where are given also references to publications that contain data for previous years.

*Discharge measurements of Wallowa River near Elgin, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 21 | R. S. Hall | 194 | 457 | 3.60 | 1,580 |
| June 28 | do | 199 | 570 | 4.14 | 2,480 |
| December 9 | Stevens and McGlashan | 135 | 264 | 2.90 | 777 |

*Daily gage height, in feet, of Wallowa River near Elgin, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.25 | 2.25 | 2.6 | 2.8 | ..... | 4.0 | 3.9 | 2.5 | 2.3 | 2.25 | 2.45 | 2.7 |
| 2 | 2.3 | 2.3 | 2.5 | 2.6 | ..... | 4.0 | 4.0 | 2.5 | 2.3 | 2.25 | 2.4 | 2.65 |
| 3 | 2.3 | 2.3 | 2.5 | 3.8 | ..... | 4.15 | 4.0 | 2.45 | 2.3 | ..... | 2.4 | 2.65 |
| 4 | 2.25 | 2.3 | 2.5 | 3.8 | ..... | 4.5 | 4.1 | 2.45 | 2.3 | ..... | 2.45 | 2.6 |
| 5 | 2.2 | 2.25 | 2.5 | 3.3 | ..... | 4.3 | 4.1 | 2.45 | 2.3 | ..... | 2.5 | 2.6 |
| 6 | 2.2 | 2.25 | 2.5 | 3.3 | ..... | 4.1 | 4.0 | 2.45 | 2.3 | 2.25 | 2.45 | 2.6 |
| 7 | 2.2 | 2.25 | 2.55 | 3.6 | ..... | 4.0 | 4.0 | 2.4 | 2.3 | 2.25 | 2.55 | 2.85 |
| 8 | 2.2 | 2.2 | 2.65 | 3.5 | ..... | 3.9 | 4.0 | 2.35 | 2.3 | 2.25 | 3.3 | 2.85 |
| 9 | 2.3 | 2.2 | 2.8 | 3.4 | ..... | 3.9 | 3.8 | 2.35 | 2.3 | 2.25 | 3.1 | 2.9 |
| 10 | 2.3 | 2.25 | 2.9 | 3.3 | ..... | 4.0 | 3.7 | 2.35 | 2.3 | 2.25 | 3.1 | 2.9 |
| 11 | 2.3 | 2.3 | 2.8 | 3.3 | ..... | 4.38 | 3.6 | 2.35 | 2.3 | 2.25 | 3.2 | 2.95 |
| 12 | 2.35 | 2.3 | 2.65 | 3.3 | ..... | 4.75 | 3.6 | 2.35 | 2.3 | 2.3 | 3.1 | 3.0 |
| 13 | 2.25 | 2.3 | 2.45 | 3.3 | ..... | 4.6 | 3.4 | 2.35 | 2.4 | 2.3 | 4.5 | 3.0 |
| 14 | 2.2 | 2.4 | 2.5 | 3.3 | ..... | 4.4 | 3.3 | 2.35 | 2.4 | 2.3 | 5.52 | 2.95 |
| 15 | 2.2 | 2.4 | 2.55 | 3.3 | ..... | 4.4 | 3.3 | 2.35 | 2.4 | 2.3 | 5.45 | 2.95 |
| 16 | 2.2 | 2.35 | 2.65 | 3.3 | ..... | 4.8 | 3.2 | 2.35 | 2.35 | 2.35 | 4.4 | 2.95 |
| 17 | 2.2 | 2.35 | 2.6 | 3.4 | ..... | 4.7 | 3.1 | 2.35 | 2.35 | 2.4 | 4.1 | 2.9 |
| 18 | 2.2 | 2.4 | 2.3 | 3.4 | ..... | 4.4 | 3.1 | 2.35 | 2.35 | 2.4 | 3.7 | 2.95 |
| 19 | 2.2 | 2.7 | 2.45 | 3.5 | ..... | 4.2 | 3.0 | 2.3 | 2.35 | 2.35 | 3.5 | 2.95 |
| 20 | 2.3 | 2.7 | 2.45 | 3.6 | 3.6 | 4.15 | 2.95 | 2.3 | 2.35 | 2.35 | 3.45 | 3.4 |
| 21 | 2.2 | 2.8 | 2.5 | 3.8 | 3.6 | 4.25 | 2.9 | 2.3 | 2.3 | 2.35 | 3.45 | 3.7 |
| 22 | 2.2 | 2.8 | 2.6 | 3.8 | 3.75 | 4.1 | 2.85 | 2.3 | 2.3 | 2.3 | 3.35 | 3.4 |
| 23 | 2.2 | 2.7 | 2.6 | 3.8 | 3.65 | 3.9 | 2.8 | 2.3 | 2.3 | 2.3 | 3.3 | 3.35 |
| 24 | 2.3 | 2.7 | 2.9 | 4.2 | 3.6 | 3.9 | ..... | 2.4 | 2.3 | 2.3 | 3.25 | 3.3 |
| 25 | 2.3 | 2.7 | 3.4 | 4.2 | 3.65 | 4.0 | 2.7 | 2.35 | 2.3 | 2.3 | 3.2 | 3.3 |
| 26 | 2.3 | 2.7 | 3.4 | 4.0 | 3.95 | 4.1 | 2.6 | 2.35 | 2.3 | 2.3 | 3.2 | 3.9 |
| 27 | 2.25 | 2.7 | 3.7 | 3.8 | 3.9 | 4.4 | 2.55 | 2.3 | 2.3 | 2.7 | 3.1 | 3.6 |
| 28 | 2.3 | 2.8 | 3.4 | 3.6 | 3.8 | 4.4 | 2.55 | 2.3 | 2.3 | 2.55 | 3.1 | 3.55 |
| 29 | 2.3 | ..... | 3.5 | ..... | 3.85 | 3.9 | 2.55 | 2.3 | 2.3 | 2.5 | 3.0 | 3.5 |
| 30 | 2.3 | ..... | 3.65 | ..... | 4.0 | 3.8 | 2.55 | 2.3 | 2.25 | 2.5 | 2.9 | 3.4 |
| 31 | 2.25 | ..... | 3.75 | ..... | 4.05 | ..... | 2.5 | 2.3 | ..... | 2.45 | ..... | 3.3 |

*Rating table for Wallowa River near Elgin, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.00 | 215 | 2.70 | 615 | 3.40 | 1,330 | 4.10 | 2,385 | 4.80 | 3,700 |
| 2.10 | 255 | 2.80 | 695 | 3.50 | 1,470 | 4.20 | 2,555 | 4.90 | 3,920 |
| 2.20 | 300 | 2.90 | 780 | 3.60 | 1,610 | 4.30 | 2,730 | 5.00 | 4,140 |
| 2.30 | 350 | 3.00 | 870 | 3.70 | 1,755 | 4.40 | 2,910 | 5.20 | 4,600 |
| 2.40 | 405 | 3.10 | 970 | 3.80 | 1,905 | 4.50 | 3,100 | 5.40 | 5,090 |
| 2.50 | 470 | 3.20 | 1,080 | 3.90 | 2,060 | 4.60 | 3,300 | | |
| 2.60 | 540 | 3.30 | 1,200 | 4.00 | 2,220 | 4.70 | 3,500 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1906 and is well defined below gage height 4.2 feet.

*Monthly discharge of Wallowa River near Elgin, Oreg., for 1906.*

[Drainage area, 870 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 378 | 300 | 326 | 20,000 | 0.375 | 0.43 |
| February | 695 | 300 | 453 | 25,200 | .521 | .54 |
| March | 1,830 | 350 | 759 | 46,700 | .872 | 1.01 |
| April 1–28 | 2,560 | 540 | 1,520 | 84,400 | 1.75 | 1.82 |
| May 20–31 | 2,300 | 1,610 | 1,880 | 44,700 | 2.16 | .96 |
| June | 3,700 | 1,900 | 2,600 | 15,500 | 2.99 | 3.34 |
| July | 2,380 | 470 | 1,280 | 78,700 | 1.47 | 1.70 |
| August | 470 | 350 | 384 | 23,600 | .441 | .51 |
| September | 405 | 325 | 359 | 21,400 | .413 | .46 |
| October | 615 | 325 | 372 | 22,900 | .428 | .49 |
| November | 5,420 | 405 | 1,420 | 84,500 | 1.63 | 1.82 |
| December | 2,060 | 540 | 1,010 | 62,100 | 1.16 | 1.34 |
| The period | ..... | ..... | ..... | 530,000 | ..... | ..... |

NOTE.—Values are rated as excellent.

## ASOTIN CREEK NEAR ASOTIN, WASH.

This station was established March 25, 1904. It is located at Shellman's ranch, about 8 miles above Asotin, Wash. Gage height observations were discontinued during 1906, as no observer was available. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 167, where are given also references to publications that contain data for previous years.

*Discharge measurements of Asotin Creek near Asotin, Wash., in 1904 and 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1904. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 25 | W. W. Schlecht | 35 | 31 | 2.03 | 113 |
| April 22 | W. G. Steward | 40 | 70 | 3.15 | 458 |
| July 1 | do | 30 | 31 | 1.79 | 92 |
| August 12 | Hulburt and Moore | 26 | 17 | 1.52 | 40 |
| 1906. | | | | | |
| December 24 | H. McGlashan | 36 | 50 | 2.30 | 215 |

*Daily gage height, in feet, of Asotin Creek near Asotin, Wash., for 1906.*

| Day. | Jan. | Feb. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.45 | 1.55 | ..... | 2.0 | 1.6 | 1.4 | 1.4 | 1.4 | 1.5 |
| 2 | 1.45 | 1.55 | ..... | 2.0 | 1.6 | 1.4 | 1.4 | 1.4 | 1.5 |
| 3 | 1.45 | 1.55 | ..... | 2.0 | 1.6 | 1.4 | 1.4 | 1.5 | 1.5 |
| 4 | 1.58 | 1.55 | ..... | 2.1 | 1.6 | 1.4 | 1.4 | 1.5 | 1.5 |
| 5 | 1.55 | 1.55 | ..... | 2.1 | 1.5 | 1.4 | 1.4 | 1.5 | 1.5 |
| 6 | 1.98 | 1.55 | ..... | 2.1 | 1.5 | 1.4 | 1.4 | 1.5 | 1.5 |
| 7 | 1.52 | 1.55 | ..... | 2.0 | 1.5 | 1.4 | 1.4 | 1.5 | 1.5 |
| 8 | 1.45 | 1.55 | ..... | 1.9 | 1.5 | 1.4 | 1.4 | 1.5 | 1.8 |
| 9 | 1.45 | 1.55 | ..... | 1.9 | 1.5 | 1.4 | 1.4 | 1.5 | 1.7 |
| 10 | 1.5 | 1.55 | ..... | 1.8 | 1.5 | 1.4 | 1.4 | 1.5 | 1.6 |
| 11 | 1.5 | 1.55 | ..... | 1.8 | 1.5 | 1.4 | 1.4 | 1.5 | 1.6 |
| 12 | 1.5 | 1.55 | ..... | 1.8 | 1.5 | 1.4 | 1.4 | 1.5 | 1.6 |
| 13 | 1.5 | 1.55 | ..... | 1.8 | 1.5 | 1.4 | 1.4 | 1.5 | 1.8 |
| 14 | 1.5 | 1.55 | ..... | 1.8 | 1.5 | 1.5 | 1.4 | 1.5 | 2.2 |
| 15 | 1.52 | 1.55 | ..... | 1.8 | 1.5 | 1.5 | 1.4 | 1.5 | 2.3 |
| 16 | 1.5 | 1.55 | ..... | 1.8 | 1.5 | 1.5 | 1.4 | 1.5 | 2.4 |
| 17 | 1.5 | 1.62 | 1.8 | 1.8 | 1.5 | 1.5 | 1.4 | 1.5 | 2.2 |
| 18 | 1.5 | ..... | 1.8 | 1.7 | 1.5 | 1.5 | 1.4 | 1.5 | 2.0 |
| 19 | 1.5 | ..... | 1.7 | 1.7 | 1.5 | 1.5 | 1.4 | 1.5 | 1.9 |
| 20 | 1.5 | ..... | 1.7 | 1.7 | 1.5 | 1.5 | 1.4 | 1.5 | 1.9 |
| 21 | 1.5 | ..... | 1.7 | 1.7 | 1.5 | 1.5 | 1.4 | 1.5 | 1.8 |
| 22 | 1.5 | ..... | 1.7 | 1.7 | 1.5 | 1.5 | 1.4 | 1.5 | 1.8 |
| 23 | 1.7 | ..... | 1.7 | 1.7 | 1.5 | 1.5 | 1.4 | 1.5 | 1.7 |
| 24 | 1.6 | ..... | 1.7 | 1.7 | 1.5 | 1.5 | 1.4 | 1.5 | 1.7 |
| 25 | 1.55 | ..... | 1.7 | 1.6 | 1.5 | 1.5 | 1.4 | 1.5 | 1.7 |
| 26 | 1.55 | ..... | 1.7 | 1.6 | 1.5 | 1.5 | 1.4 | 1.5 | 1.7 |
| 27 | 1.55 | ..... | 1.7 | 1.6 | 1.5 | 1.5 | 1.4 | 1.5 | 1.7 |
| 28 | 1.55 | ..... | 1.7 | 1.6 | 1.5 | 1.5 | 1.4 | 1.5 | 1.6 |
| 29 | 1.55 | ..... | 1.9 | 1.6 | 1.5 | 1.5 | 1.4 | 1.5 | 1.6 |
| 30 | 1.55 | ..... | 2.1 | 1.6 | 1.5 | 1.5 | 1.4 | 1.5 | 1.6 |
| 31 | 1.55 | ..... | 2.1 | ..... | 1.5 | 1.4 | ..... | 1.5 | ..... |

*Rating table for Asotin Creek near Asotin, Wash., for 1904–1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.40 | 29 | 2.00 | 126 | 2.60 | 277 | 3.20 | 502 | 3.80 | 829 |
| 1.50 | 40 | 2.10 | 147 | 2.70 | 309 | 3.30 | 549 | 3.90 | 894 |
| 1.60 | 54 | 2.20 | 169 | 2.80 | 343 | 3.40 | 599 | 4.00 | 962 |
| 1.70 | 70 | 2.30 | 193 | 2.90 | 379 | 3.50 | 652 | 4.10 | 1,032 |
| 1.80 | 87 | 2.40 | 219 | 3.00 | 417 | 3.60 | 708 | 4.20 | 1,104 |
| 1.90 | 106 | 2.50 | 247 | 3.10 | 458 | 3.70 | 767 | 4.30 | 1,179 |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 5 discharge measurements made during 1904–1906 and is not well defined.

*Monthly discharge of Asotin Creek near Asotin, Wash., for 1904–1906.*

[Drainage area, 171 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1904. | | | | | | |
| March 21–31 | 193 | 116 | 156 | 3,400 | 0.912 | 0.37 |
| April | 1,180 | 198 | 469 | 27,900 | 2.74 | 3.06 |
| May | 417 | 219 | 276 | 17,000 | 1.61 | 1.86 |
| June | 277 | 78 | 159 | 9,460 | .930 | 1.04 |
| July | 116 | 50 | 70.8 | 4,350 | .414 | .48 |
| August | 54 | 44 | 47.0 | 2,890 | .275 | .32 |
| September | 64 | 44 | 47.3 | 2,810 | .277 | .31 |
| October | 85 | 47 | 50.5 | 3,100 | .295 | .34 |
| November 1–19 | 47 | 47 | 47.0 | 1,770 | .275 | .19 |
| The period | | | | 72,700 | | |
| 1905. | | | | | | |
| April | 96 | 62 | 80.3 | 4,780 | 0.470 | 0.52 |
| May | 106 | 78 | 91.8 | 5,640 | .537 | .62 |
| June | 283 | 54 | 189 | 11,200 | 1.11 | 1.24 |
| July | 70 | 34 | 43.1 | 2,650 | .252 | .29 |
| August | 34 | 34 | 34.0 | 2,090 | .199 | .23 |
| September | 62 | 34 | 36.2 | 2,150 | .212 | .24 |
| October | 47 | 40 | 40.7 | 2,500 | .238 | .28 |
| November | 40 | 34 | 39.1 | 2,330 | .229 | .26 |
| December | 47 | 34 | 38.9 | 2,390 | .228 | .26 |
| The period | | | | 35,700 | | |
| 1906. | | | | | | |
| January | 122 | 34 | 45.5 | 2,800 | 0.266 | 0.31 |
| February 1–17 | 57 | 47 | 47.6 | 1,600 | .278 | .18 |
| May 17–31 | 147 | 70 | 85.0 | 2,530 | .497 | .28 |
| June | 147 | 54 | 89.0 | 5,300 | .520 | .58 |
| July | 54 | 40 | 41.8 | 2,570 | .244 | .28 |
| August | 40 | 29 | 35.0 | 2,150 | .205 | .24 |
| September | 29 | 29 | 29.0 | 1,730 | .170 | .19 |
| October | 40 | 29 | 39.3 | 2,420 | .230 | .27 |
| November | 219 | 40 | 82.5 | 4,910 | .482 | .54 |
| The period | | | | 26,000 | | |

NOTE.—Values are rated as fair.

## PALOUSE RIVER AT HOOPER, WASH.

The gaging station at Hooper, Wash., was originally established April 1, 1897, by the land department of the Northern Pacific Railway. The United States Geological Survey assumed charge September 9, 1897, and moved the station about 1 mile downstream.

The measurements are of value in showing the amount of water available for use on lands of Washtucna Valley and in the section

north of Pasco. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 171, where are given also references to publications that contain data for previous years.

*Daily gage height, in feet, of Palouse River at Hooper, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.5 | 3.6 | 4.75 | 5.3 | 3.2 | 3.7 | 1.65 | 0.9 | 0.8 | 0.8 | 0.9 | 1.6 |
| 2 | 1.6 | 3.5 | 4.7 | 5.75 | 3.0 | 3.5 | 1.6 | .9 | .8 | .8 | .9 | 1.6 |
| 3 | 1.55 | 3.6 | 4.4 | 6.0 | 2.4 | 2.45 | 1.6 | .85 | .8 | .8 | .95 | 1.6 |
| 4 | 1.5 | 4.05 | 4.1 | 5.85 | 2.3 | 2.7 | 1.6 | .8 | .8 | .8 | 1.0 | 1.55 |
| 5 | 1.6 | 3.5 | 3.6 | 5.7 | 2.15 | 3.5 | 1.6 | .8 | .8 | .8 | 1.0 | 1.5 |
| 6 | 1.65 | 3.5 | 3.9 | 5.6 | 2.5 | 3.05 | 1.5 | .8 | .8 | .8 | 1.0 | 1.65 |
| 7 | 1.7 | 3.05 | 3.6 | 4.4 | 2.4 | 2.45 | 1.4 | .8 | .8 | .8 | 1.05 | 1.8 |
| 8 | 1.8 | 2.9 | 3.6 | 4.4 | 2.2 | 2.55 | 1.35 | .8 | .8 | .8 | 1.15 | 2.05 |
| 9 | 2.0 | 2.9 | 3.6 | 4.3 | 2.2 | 2.6 | 1.5 | .75 | .8 | .8 | 1.2 | 3.05 |
| 10 | 1.95 | 2.8 | 3.8 | 4.9 | 2.2 | 2.4 | 1.4 | .75 | .8 | .8 | 1.35 | 2.7 |
| 11 | 1.95 | 2.8 | 5.15 | 4.8 | 2.15 | 2.55 | 1.35 | .75 | .8 | .8 | 1.6 | 2.7 |
| 12 | 1.85 | 2.85 | 4.9 | 4.75 | 2.1 | 2.4 | 1.3 | .75 | .8 | .8 | 1.8 | 2.9 |
| 13 | 1.85 | 2.8 | 3.4 | 4.6 | 2.0 | 2.3 | 1.25 | .75 | .8 | .85 | 2.1 | 3.05 |
| 14 | 2.0 | 2.7 | 4.9 | 3.6 | 2.0 | 2.3 | 1.2 | .8 | .8 | .9 | 2.4 | 3.4 |
| 15 | 2.35 | 2.75 | 4.0 | 3.4 | 2.0 | 2.25 | 1.7 | .8 | .8 | .9 | 3.3 | 2.8 |
| 16 | 2.3 | 2.7 | 3.6 | 3.9 | 2.1 | 2.2 | 1.4 | .8 | .8 | .9 | 3.8 | 2.7 |
| 17 | 2.35 | 3.1 | 3.5 | 3.5 | 2.1 | 2.2 | 1.3 | .75 | .8 | .9 | 4.1 | 2.7 |
| 18 | 2.3 | 3.2 | 3.5 | 3.4 | 2.05 | 2.1 | 1.2 | .75 | .8 | .9 | 4.4 | 2.6 |
| 19 | 2.2 | 3.3 | 3.3 | 3.4 | 2.05 | 2.1 | 1.15 | .7 | .8 | .9 | 3.05 | 2.6 |
| 20 | 1.95 | 5.05 | 3.6 | 3.4 | 2.05 | 2.05 | 1.15 | .7 | .8 | .9 | 2.6 | 3.7 |
| 21 | 1.85 | 6.1 | 3.5 | 3.25 | 2.05 | 2.0 | 1.1 | .7 | .8 | .9 | 2.5 | 6.1 |
| 22 | 2.0 | 6.35 | 2.95 | 3.1 | 2.0 | 2.0 | 1.05 | .7 | .8 | .9 | 2.3 | 8.7 |
| 23 | 2.35 | 5.7 | 3.2 | 3.05 | 2.0 | 2.0 | 1.05 | .7 | .8 | .9 | 2.2 | 9.8 |
| 24 | 3.15 | 5.65 | 3.25 | 3.0 | 1.9 | 1.95 | 1.05 | .7 | .8 | .9 | 2.1 | 8.2 |
| 25 | 3.3 | 5.15 | 3.4 | 2.9 | 1.85 | 1.85 | 1.05 | .7 | .8 | .9 | 2.0 | 7.1 |
| 26 | 3.7 | 5.0 | 3.6 | 3.4 | 1.8 | 1.6 | 1.05 | .7 | .8 | .9 | 1.85 | 6.8 |
| 27 | 4.2 | 4.8 | 4.9 | 3.1 | 1.75 | 1.7 | 1.0 | .7 | .8 | .95 | 1.6 | 7.0 |
| 28 | 4.05 | 4.75 | 5.4 | 3.0 | 1.7 | 1.6 | 1.0 | .7 | .8 | .95 | 1.5 | 7.4 |
| 29 | 4.0 | ..... | 6.1 | 2.9 | 2.2 | 1.65 | .95 | .7 | .8 | .95 | 1.5 | 6.8 |
| 30 | 3.9 | ..... | 6.4 | 3.0 | 3.8 | 1.75 | .95 | .7 | .8 | .95 | 1.6 | 7.1 |
| 31 | 3.6 | ..... | 5.8 | ..... | 2.7 | ..... | .95 | .75 | ..... | .9 | ..... | 7.6 |

*Rating table for Palouse River at Hooper, Wash., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.60 | 10 | 1.70 | 110 | 2.80 | 331 | 3.90 | 670 | 6.00 | 1,965 |
| 0.70 | 13 | 1.80 | 125 | 2.90 | 355 | 4.00 | 715 | 6.20 | 2,120 |
| 0.80 | 17 | 1.90 | 141 | 3.00 | 380 | 4.20 | 805 | 6.40 | 2,285 |
| 0.90 | 22 | 2.00 | 158 | 3.10 | 405 | 4.40 | 900 | 6.60 | 2,440 |
| 1.00 | 28 | 2.10 | 176 | 3.20 | 430 | 4.60 | 1,015 | 6.80 | 2,620 |
| 1.10 | 36 | 2.20 | 195 | 3.30 | 457 | 4.80 | 1,135 | 7.00 | 2,800 |
| 1.20 | 46 | 2.30 | 215 | 3.40 | 486 | 5.00 | 1,265 | 8.00 | 3,780 |
| 1.30 | 57 | 2.40 | 236 | 3.50 | 517 | 5.20 | 1,400 | 9.00 | 4,900 |
| 1.40 | 69 | 2.50 | 259 | 3.60 | 551 | 5.40 | 1,540 | 10.00 | 6,200 |
| 1.50 | 82 | 2.60 | 283 | 3.70 | 588 | 5.60 | 1,680 | | |
| 1.60 | 96 | 2.70 | 307 | 3.80 | 628 | 5.80 | 1,820 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1906 and is well defined between gage heights 0.8 feet and 10.0 feet.

*Monthly discharge of Palouse River at Hooper, Wash., for 1906.*

[Drainage area, 2,210 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 805 | 82 | 269 | 16,500 | 0.122 | 0.14 |
| February | 2,240 | 307 | 784 | 43,500 | .355 | .37 |
| March | 2,280 | 367 | 857 | 52,700 | .388 | .45 |
| April | 1,960 | 355 | 842 | 50,100 | .381 | .43 |
| May | 628 | 110 | 208 | 12,800 | .094 | .11 |
| June | 588 | 96 | 231 | 13,700 | .105 | .12 |
| July | 110 | 25 | 56.8 | 3,490 | .026 | .03 |
| August | 22 | 13 | 15.3 | 941 | .0069 | .01 |
| September | 17 | 17 | 17.0 | 1,010 | .0077 | .01 |
| October | 25 | 17 | 20.4 | 1,250 | .0092 | .01 |
| November | 900 | 22 | 196 | 11,700 | .089 | .10 |
| December | 5,920 | 82 | 1,360 | 83,600 | .615 | .71 |
| The year | 5,920 | 13 | 405 | 291,000 | .183 | 2.49 |

NOTE.—Values are rated as good.

## MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in Snake River drainage basin in 1906:

*Asotin Creek at Asotin, Wash.*—This station, which was discontinued December 31, 1905, is described in Water-Supply Paper No. 178, page 167. A measurement was made December 21, 1906.

Width, 52 feet; area, 68 square feet; gage height, 3.97 feet; discharge, 290 second-feet.

*Bear Creek near Wallowa, Oreg.*—The reference point is on top of the lower end of the left floor beam; gage heights are distances below reference point.

May 22, width 35 feet; area, 55 square feet; gage height, −7.66 feet; discharge, 226 second-feet.

June 26, width, 37 feet; area, 62 square feet; gage height, −7.45 feet; discharge, 259 second-feet.

*Five point Creek near Hilgard, Oreg.*—A measurement was made just above the mouth March 10, 1906. The water surface was 6.34 feet below the top of the highway bridge floor, upstream side, at a point 23 feet from the right end of the floor.

Width, 25 feet; area, 45 square feet; discharge, 157 second-feet.

A measurement was made at low water December 4, 1906. The water surface was 7.15 feet below a bent spike in the downstream side of the top log of the right abutment of the highway bridge.

Width, 20 feet; area, 21 square feet; discharge, 7.4 second-feet.

*Minam Creek near Lovely, Oreg.*—The discharge of this stream was found December 9, 1906, by taking the difference of the discharges of Wallowa River above and below its mouth. Discharge, 228 second-feet.

*Wallowa River near Lovely, Oreg.*—A measurement was made at medium stage, December 9, 1906, at the footbridge just below Canyon stage stations and above the mouth of Minam Creek. The water surface was 1.08 feet below a small ledge of projecting rock on the right bank, 9.0 feet vertically underneath a point on the top of the downstream log of the footbridge, 7.5 feet from the right end of the log.

Width, 85 feet; area, 186 square feet; discharge, 549 second-feet.

*Miscellaneous measurements in Snake River drainage basin in 1906.*

| Date. | Stream. | Locality. | Width. | Area of section. | Discharge. |
|---|---|---|---|---|---|
| | | | *Feet.* | *Sq. ft.* | *Sec.-ft.* |
| January 9 | Boise River | Below Barber dam and 7 miles above Boise, Idaho. | 144 | 261 | 562 |
| April 4 | Burnt River | Huntington, Oreg. | 78 | 156 | 696 |
| August 6 | Cedar Creek | In canyon, 8 miles above Mackay, Idaho. | 10 | 6.2 | 12.5 |
| July 19 | North Fork Buffalo River | At most northerly meadows, Wyoming. | 62 | 75 | 165 |
| September 8 | John Day River | Junction with South Fork Snake River, Wyoming. | 42 | 104 | 592 |

## WALLA WALLA RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Walla Walla River heads on the northwestern slope of the Blue Mountains in northeastern Oregon and southeastern Washington, flows westward, and unites with the Columbia at Wallula, Wash. The Blue Mountains have an elevation of approximately 2,000 feet above the surrounding country; their northwestern slope is drained by the numerous tributaries of the Walla Walla and their southeastern slope by those of Grande Ronde River, a tributary of the Snake. The drainage basin is a broad, triangular-shaped area, aggregating 1,050 square miles. Except on the mountain slopes the area is timberless, being composed of rolling table-lands devoted largely to the production of wheat. The valleys are level tracts in which irrigation has reached a high stage of development. The rainfall at Walla Walla, Wash., is about 18 inches per annum. The principal tributaries of the stream are Little Walla Walla River, Mill Creek, on which the city of Walla Walla is situated, Garrison Creek, Yellowhawk Creek, Cottonwood Creek, and South Fork of Walla Walla River.

The main stream and its tributaries are used extensively for irrigation and power. The power plant of the Northwestern Gas and Electric Company, from which the cities of Pendleton, Walla Walla, Weston, and neighboring towns are connected by an electric line, is located on South Fork of Walla Walla River, about 12 miles above Milton.

## WALLA WALLA RIVER NEAR MILTON, OREG.

This station was established August 12, 1905, to replace the station at Milton, Oreg., one-half mile below. It was located near the old city reservoir, 1½ miles above Milton, but the gage, cable, and bench mark were destroyed by flood May 30, 1906, and on August 16, 1906, the station was reestablished at West's highway bridge, 3 miles above Milton. A small ditch heads just above the bridge.

The channel is straight above the station and curved below. The water is shallow and the current swift. The banks are low and liable to overflow. The bed of the stream is composed of clean sand and gravel and liable to shift. There is one channel at all stages.

Measurements are made from the bridge. The initial point is the face of the right abutment.

The gage, which is read by Maud Osborn, is a 2 by 6 inch timber spiked vertically to the right abutment. The bench mark is a 20-penny spike in pole 1170 of a transmission line at the southwest corner of the bridge; elevation, 9.03 feet above the datum of the gage.

The conditions at the old station and the bench marks are described in Water-Supply Paper No. 178, page 178, where are given also references to publications that contain data for previous years.

*Discharge measurements of Walla Walla River near Milton, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 19 | R. S. Hall | 60 | 91 | [a] 4.62 | 413 |
| March 23 | Cupper and Buchanan | 47 | 60 | [a] 4.11 | 181 |
| May 22 | P. A. Cupper | 45 | 66 | [a] 4.13 | 187 |
| June 28 [b] | do | 45 | 59 | ..... | 186 |
| July 21 [b] | do | 44 | 56 | ..... | 112 |
| August 4 [b] | do | 43 | 50 | ..... | 99 |
| August 29 | do | 43 | 52 | [c] 1.63 | 97 |
| December 11 | H. McGlashan | 63 | 72 | [c] 2.20 | 300 |

[a] Gage near city reservoir.
[b] Measured by wading at mouthof Couse Creek.
[c] Gage at West's bridge.

*Daily gage height, in feet, of Walla Walla River near Milton, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.02 | 4.28 | 4.38 | 4.70 | 4.45 | [a] 1.35 | 1.65 | 1.75 | 1.95 |
| 2 | 4.00 | 4.28 | 4.32 | 4.60 | 4.45 | 1.55 | 1.75 | 1.75 | 1.95 |
| 3 | 4.00 | 4.20 | 4.28 | 4.60 | 4.48 | 1.45 | 1.75 | 1.65 | 1.85 |
| 4 | 4.02 | 4.20 | 4.28 | 4.60 | 4.45 | 1.65 | 1.65 | 1.70 | 1.85 |
| 5 | 4.10 | 4.18 | 4.22 | 4.60 | 4.35 | 1.65 | 1.85 | 1.75 | 1.90 |
| 6 | 4.22 | 4.15 | 4.22 | 4.62 | 4.35 | 1.55 | 1.75 | 1.75 | 1.95 |
| 7 | 4.32 | 4.10 | 4.25 | 4.62 | 4.30 | 1.35 | 1.75 | 1.85 | 2.05 |
| 8 | 4.30 | 4.10 | 4.30 | 4.65 | 4.30 | 1.65 | 1.65 | 1.85 | 2.05 |
| 9 | 4.22 | 4.08 | 4.38 | 4.70 | 4.30 | 1.55 | 1.75 | 1.90 | 2.15 |
| 10 | 4.20 | 4.08 | 4.38 | 4.60 | 4.30 | 1.65 | 1.75 | 1.95 | 2.05 |
| 11 | 4.20 | 4.08 | 4.35 | 4.55 | 4.30 | 1.55 | 1.75 | 2.65 | 2.05 |
| 12 | 4.18 | 4.05 | 4.32 | 4.45 | 4.30 | 1.55 | 1.65 | 2.85 | 2.35 |
| 13 | 4.22 | 4.02 | 4.25 | 4.42 | 4.25 | 1.65 | 1.75 | 2.75 | 2.30 |
| 14 | 4.22 | 4.02 | 4.22 | 4.48 | 4.25 | 1.75 | 1.75 | 2.95 | 2.20 |
| 15 | 4.20 | 4.05 | 4.22 | 4.50 | 4.28 | 1.75 | 1.75 | 3.25 | 2.15 |

*Daily gage height, in feet, of Walla Walla River near Milton, Oreg., in 1906*—Con.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|
| 16 | 4.28 | 4.05 | 4.20 | 4.58 | 4.22 | 1.75 | 1.85 | 3.65 | 2.20 |
| 17 | 4.22 | 4.05 | 4.15 | 4.55 | 4.15 | 1.75 | 1.75 | 2.95 | 2.20 |
| 18 | 4.20 | 4.20 | 4.12 | 4.52 | 4.25 | 1.75 | 1.75 | 2.75 | 2.25 |
| 19 | 4.18 | 4.60 | 4.10 | 4.52 | 4.25 | 1.65 | 1.75 | 2.65 | 2.35 |
| 20 | 4.12 | 4.60 | 4.10 | 4.52 | 4.12 | 1.75 | 1.75 | 2.55 | 2.15 |
| 21 | 4.10 | 4.60 | 4.10 | 4.62 | 4.13 | 1.75 | 1.65 | 2.35 | 4.00 |
| 22 | 4.12 | 4.55 | 4.10 | 4.70 | 4.12 | 1.75 | 1.75 | 2.15 | 3.40 |
| 23 | 4.18 | 4.45 | 4.10 | 4.65 | 4.13 | 1.85 | 1.75 | 2.05 | 3.00 |
| 24 | 4.40 | 4.42 | 4.25 | 4.60 | 4.12 | 1.85 | 1.70 | 1.95 | 2.95 |
| 25 | 4.50 | 4.38 | 4.30 | 4.52 | 4.10 | 1.75 | 1.75 | 1.95 | 2.95 |
| 26 | 4.45 | 4.35 | 4.32 | 4.48 | 4.12 | 1.75 | 1.75 | 1.95 | 2.90 |
| 27 | 4.40 | 4.40 | 4.62 | 4.45 | 4.13 | 1.75 | 1.65 | 1.90 | 2.85 |
| 28 | 4.32 | 4.40 | 4.62 | 4.45 | 4.12 | 1.85 | 1.75 | 1.85 | 2.85 |
| 29 | 4.30 | ..... | 4.58 | 4.45 | 5.90 | 1.75 | 1.70 | 1.80 | 2.80 |
| 30 | 4.28 | ..... | 4.60 | 4.45 | (b) | 1.65 | 1.75 | 1.85 | 2.75 |
| 31 | 4.25 | ..... | 4.72 | ..... | ..... | ..... | 1.75 | ..... | 2.75 |

[a] On gage at West's bridge. [b] Gage and cable washed away by flood.

*Rating table for Walla Walla River near Milton, Oreg., from January 1 to May 29, 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.80 | 94 | 4.10 | 175 | 4.30 | 251 | 4.50 | 349 | 4.70 | 469 |
| 3.90 | 117 | 4.20 | 210 | 4.40 | 297 | 4.60 | 406 | 4.80 | 534 |
| 4.00 | 144 | | | | | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is well defined below gage height 4.2 feet.

*Monthly discharge of Walla Walla River near Milton, Oreg., for 1906.*

[Drainage area, 130 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 349 | 144 | 221 | 13,600 | 1.70 | 1.96 |
| February | 406 | 150 | 239 | 13,300 | 1.84 | 1.92 |
| March | 482 | 175 | 260 | 16,000 | 2.00 | 2.31 |
| April | 469 | 307 | 384 | 22,800 | 2.95 | 3.29 |
| May 1–29 | 1,370 | 175 | 274 | 15,800 | 2.11 | 2.28 |
| The period | ..... | ..... | ..... | 81,500 | ..... | ..... |

NOTE.—Values are rated as excellent.

## SOUTH FORK OF WALLA WALLA RIVER NEAR MILTON, OREG.

This station was originally established February 15, 1903, 6 miles above the mouth of the river and 12 miles from Milton, Oreg. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 176, where are given also references to publications that contain data for previous years.

The flood of May 30, 1906, entirely changed the channel. On August 10, 1906, a new station was established one-fourth mile above the headgate of the Northwestern Gas and Electric Company's pipe line. This point is above all diversions.

The channel is straight for 200 feet above and below the station. The banks are low and liable to overflow. There is one channel at all stages. The bed of the stream is of gravel and will change during high floods. The current is swift at all stages.

Measurements are made by wading 17 feet below the gage. The initial point for soundings is a blaze on a cottonwood tree on the left bank.

Gage heights are furnished by the Northwestern Gas and Electric Company, through Mr. Paul Young. The gage is a 2 by 6 inch timber, spiked in a vertical position to a tree on the left bank. The bench mark is a spike in the roots of a large cottonwood tree on the left bank, 10 feet from the gage; elevation, 7.74 feet above the datum of the gage.

*Discharge measurements of South Fork of Walla Walla River near Milton, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 20 | R. S. Hall | 48 | 71 | [a] 2.10 | 390 |
| March 23 | P. A. Cupper | 45 | 41 | [a] 1.50 | 159 |
| May 24 | do | 45 | 48 | [a] 1.66 | 171 |
| August 10 | J. C. Stevens | 45 | 49 | [b] 2.50 | 120 |
| December 13 | H. McGlashan | 42 | 56 | [b] 3.73 | 183 |

[a] Gage at bridge. [b] Gage at headgate.

*Daily gage height, in feet, of South Fork of Walla Walla River near Milton, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 1.7 | 1.7 | 2.0 | 2.0 | 1.2 | ..... | 2.5 |
| 2 | 1.55 | 1.7 | 1.65 | 2.0 | 2.0 | ..... | ..... | 2.5 |
| 3 | 1.55 | ..... | 1.65 | 2.0 | ..... | 1.0 | ..... | 2.5 |
| 4 | ..... | 1.65 | 1.65 | 2.0 | 2.0 | ..... | ..... | 2.5 |
| 5 | 1.6 | 1.6 | 1.6 | 2.0 | 1.95 | ..... | ..... | 2.5 |
| 6 | 1.7 | 1.6 | 1.6 | 2.0 | 1.9 | ..... | ..... | 2.5 |
| 7 | ..... | 1.6 | 1.6 | 2.1 | 1.85 | ..... | ..... | 2.5 |
| 8 | 1.65 | 1.6 | 1.7 | 2.1 | 1.8 | ..... | ..... | 2.5 |
| 9 | 1.65 | 1.6 | ..... | 2.1 | 1.85 | ..... | ..... | 2.52 |
| 10 | 1.7 | ..... | 1.7 | 2.0 | ..... | ..... | 2.5 | 2.52 |
| 11 | 1.65 | 1.55 | ..... | ..... | 1.9 | ..... | 2.5 | 2.51 |
| 12 | ..... | 1.55 | ..... | 1.8 | 1.9 | ..... | 2.53 | 2.5 |
| 13 | 1.65 | 1.55 | ..... | 1.8 | 1.85 | ..... | 2.55 | 2.55 |
| 14 | 1.65 | 1.55 | ..... | 1.8 | 1.85 | ..... | 2.52 | 2.56 |
| 15 | 1.65 | 1.55 | 1.5 | 1.9 | 1.8 | ..... | 2.52 | 2.55 |
| 16 | 1.7 | 1.55 | ..... | 1.9 | ..... | ..... | 2.51 | ..... |
| 17 | 1.7 | ..... | ..... | 1.9 | 1.75 | ..... | 2.51 | ..... |
| 18 | 1.7 | ..... | 1.5 | 1.9 | 1.7 | ..... | 2.52 | ..... |
| 19 | 1.7 | 2.2 | 1.5 | 1.9 | 1.7 | ..... | 2.5 | ..... |
| 20 | ..... | 2.0 | 1.5 | 1.95 | 1.7 | ..... | 2.5 | ..... |
| 21 | 1.65 | 2.1 | 1.5 | 2.0 | ..... | ..... | 2.5 | ..... |
| 22 | 1.65 | 2.0 | ..... | 2.2 | 1.7 | ..... | 2.57 | ..... |
| 23 | 1.8 | 1.9 | 1.5 | 2.2 | 1.7 | ..... | 2.55 | ..... |
| 24 | 1.8 | 1.8 | 1.6 | 2.1 | ..... | ..... | 2.53 | ..... |
| 25 | 1.95 | 1.8 | 1.7 | 2.05 | ..... | ..... | 2.52 | ..... |
| 26 | 1.9 | 1.8 | 2.0 | 2.0 | 1.7 | ..... | 2.52 | ..... |
| 27 | 1.8 | 1.75 | 2.0 | 1.95 | 1.7 | ..... | 2.52 | ..... |
| 28 | 1.75 | 1.75 | 2.0 | 1.9 | 1.7 | ..... | 2.5 | ..... |
| 29 | 1.7 | ..... | 2.0 | 1.95 | 2.86 | ..... | 2.5 | ..... |
| 30 | 1.7 | ..... | 1.95 | 2.0 | ..... | ..... | 2.5 | ..... |
| 31 | 1.7 | ..... | 2.15 | ..... | ..... | ..... | 2.5 | ..... |

### MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in Walla Walla River drainage basin during 1906:

*Couse Creek near Milton, Oreg.*—March 23, discharge, 10 second-feet; August 10, dry.

*Dry Creek near Milton, Oreg.*—A measurement was made 500 feet below the crossing of Finis Irrigation Company's flume. The water surface was 0.5 foot below the bench mark on a rock 50 feet above the section.

Width, 18 feet; area, 10 square feet; discharge, 13 second-feet.

*Walla Walla River at Milton, Oreg.*—The following discharges were computed from slope measurements for the spring and fall floods:

May 30, width, 316 feet; area, 924 square feet; discharge, 8,130 second-feet.
November 14, width, 281 feet; area, 632 square feet; discharge, 4,550 second-feet.

*North Fork of Walla Walla River near Milton, Oreg.*—Measurements were made near the junction with South Fork.

March 23, width, 17 feet; area, 12 square feet; discharge, 28 second-feet.
March 24, width, 16 feet; area, 8 square feet; discharge, 21 second-feet.
August 29, width, 12 feet; area, 12 square feet; discharge, 7 second-feet.

## UMATILLA RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Umatilla River rises in the western slopes of the Blue Mountains in northeastern Oregon, flows westward, and joins Columbia River at the town of Umatilla. Its drainage area is timberless except on the mountain slopes, and is composed of rolling table-lands devoted largely to the production of wheat. The rainfall on the drainage area varies from 24 inches on the headwaters to 10 inches at the mouth.

The waters of this stream are used for both power and irrigation purposes, and it is one of the most important rivers in the State.

### UMATILLA RIVER AT GIBBON, OREG.

This station was established July 22, 1896. It is located about 1 mile west of Bingham Springs Railroad station (Gibbon post-office), Oreg. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 181, where are given also references to publications that contain data for previous years.

The gage at this station was read during a portion of 1906 by J. C. Hilliard. The gage was washed out May 30, 1906, and on December 3 a new one was installed about 50 feet upstream from the cable on the left bank. It consists of a 2 by 6 inch timbers, in two sections, spiked to cottonwood trees. The bench mark is a spike in the root of a 16-inch yellow pine, 415 feet from the initial point for soundings, 160 feet from the railroad track, and 20 feet upstream from the line of the cable extended; elevation, 9.03 feet above the datum of the gage.

*Discharge measurements of Umatilla River at Gibbon, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 1 | R. S. Hall | 53 | 67 | [a]1.80 | 351 |
| March 14 | do | 55 | 80 | [a]1.85 | 415 |
| April 2 | do | 117 | 260 | [a]3.28 | 1,680 |
| April 21 | J. C. Stevens | 112 | 203 | [a]2.80 | 1,310 |
| May 26 | R. S. Hall | 44 | 44 | [a]1.40 | 203 |
| June 6 | do | 112 | 307 | ..... | 1,390 |
| July 9 | do | 86 | 80 | ..... | 102 |
| December 3 | Stevens and McGlashan | 102 | 132 | [b]1.50 | 183 |

[a] Old gage. [b] New gage.

*Daily gage height, in feet, of Umatilla River at Gibbon, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | Dec. | Day. | Jan. | Feb. | Mar. | Apr. | May. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.45 | ..... | 1.9 | 3.7 | 2.2 | ..... | 17 | 1.6 | ..... | 1.7 | 2.4 | 1.5 | 1.9 |
| 2 | 1.4 | 1.8 | 1.9 | 3.25 | ..... | ..... | 18 | 1.6 | 1.7 | 1.7 | 2.4 | 1.45 | 1.9 |
| 3 | 1.4 | 1.8 | 1.8 | 2.9 | 2.0 | [a]1.5 | 19 | 1.55 | 2.4 | ..... | 2.4 | 1.4 | 1.9 |
| 4 | 1.5 | 1.8 | 1.8 | 2.9 | 2.0 | 1.5 | 20 | 1.55 | 2.3 | 1.5 | 2.7 | 1.4 | 5.2 |
| 5 | 1.5 | 1.8 | 1.8 | 2.8 | 2.0 | 1.5 | 21 | 1.5 | 2.4 | 1.5 | 2.8 | 1.4 | 5.8 |
| 6 | ..... | 1.7 | 1.8 | 2.9 | 1.95 | 1.6 | 22 | 1.5 | 2.3 | 1.5 | 2.9 | 1.4 | 4.5 |
| 7 | 1.8 | 1.6 | 1.8 | 3.3 | 1.9 | 2.1 | 23 | ..... | 2.2 | 1.5 | ..... | 1.4 | 3.8 |
| 8 | 1.7 | 1.6 | 2.05 | ..... | 1.8 | 2.5 | 24 | 2.0 | 2.0 | 2.0 | 2.5 | 1.4 | 3.6 |
| 9 | 1.65 | 1.6 | 2.3 | ..... | 1.8 | 2.4 | 25 | 2.25 | 2.0 | 2.7 | 2.5 | 1.4 | 3.7 |
| 10 | 1.65 | 1.55 | 2.4 | 2.9 | 1.75 | 2.2 | 26 | 2.1 | 2.0 | 2.75 | 2.5 | 1.4 | 4.1 |
| 11 | 1.6 | 1.5 | ..... | 2.8 | 1.75 | 2.2 | 27 | 2.0 | ..... | 3.4 | 2.4 | 1.4 | 3.7 |
| 12 | 1.7 | 1.5 | 2.0 | 2.5 | 1.7 | 2.2 | 28 | 1.95 | ..... | 3.3 | 2.4 | 1.7 | 3.6 |
| 13 | 1.65 | 1.5 | 1.9 | 2.5 | 1.7 | 2.1 | 29 | 1.9 | ..... | 3.0 | 2.4 | ..... | 3.4 |
| 14 | 1.6 | 1.5 | ..... | 2.4 | 1.7 | 2.0 | 30 | 1.9 | ..... | 3.5 | 2.3 | [b] | 3.1 |
| 15 | 1.6 | 1.5 | ..... | 2.5 | 1.6 | 2.0 | 31 | 1.85 | ..... | 4.1 | ..... | ..... | 3.0 |
| 16 | 1.6 | 1.5 | 1.7 | 2.4 | 1.5 | 1.9 | | | | | | | |

[a] New gage installed December 3. No relation determined for the two gages.
[b] Gage destroyed by flood.

*Rating table for Umatilla River at Gibbon, Oreg., from January 1 to May 29, 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.40 | 190 | 2.00 | 555 | 2.60 | 1,075 | 3.20 | 1,660 | 3.80 | 2,305 |
| 1.50 | 233 | 2.10 | 635 | 2.70 | 1,170 | 3.30 | 1,765 | 3.90 | 2,415 |
| 1.60 | 284 | 2.20 | 720 | 2.80 | 1,265 | 3.40 | 1,870 | 4.00 | 2,530 |
| 1.70 | 343 | 2.30 | 805 | 2.90 | 1,360 | 3.50 | 1,975 | 4.10 | 2,645 |
| 1.80 | 408 | 2.40 | 895 | 3.00 | 1,460 | 3.60 | 2,085 | | |
| 1.90 | 479 | 2.50 | 985 | 3.10 | 1,560 | 3.70 | 2,195 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is well defined below gage heights 3.0 feet.

*Monthly discharge of Umatilla River at Gibbon, Oreg., for 1906.*

[Drainage area, 353 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 762 | 190 | 352 | 21,600 | 1.00 | 1.15 |
| February | 895 | 233 | 441 | 24,500 | 1.25 | 1.30 |
| March | 2,640 | 233 | 734 | 45,100 | 2.08 | 2.40 |
| April | 2,200 | 805 | 1,190 | 70,800 | 3.37 | 3.76 |
| May 1–28 | 720 | 190 | 344 | 19,100 | .975 | 1.02 |
| The period | ..... | ..... | ..... | 181,000 | ..... | ..... |

NOTE.—Values January to May are rated as good.

## UMATILLA RIVER AT YOAKUM, OREG.

This station was established May 5, 1903. It is located one-half mile east of Yoakum, a station of the Oregon Railroad and Navigation Company, at what is known as the Yoakum wagon bridge. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 185, where are given also references to publications that contain data for previous years.

*Discharge measurements of Umatilla River at Yoakum, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 19 | R. S. Hall | 75 | 224 | 4.45 | 516 |
| April 20 | J. C. Stevens | 76 | 352 | 5.98 | 1,570 |
| June 2 | R. S. Hall | ..... | 531 | 8.30 | 4,780 |
| July 11 | ....do | 74 | 154 | 3.20 | 93 |
| November 26[a] | H. McGlashan | 76 | 229 | 4.05 | 284 |

[a] Some slack water and eddies.

*Daily gage height, in feet, of Umatilla River at Yoakum, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.3 | 5.3 | 5.3 | 8.05 | 5.0 | 9.5 | 3.7 | 2.7 | 2.8 | 2.9 | 3.2 | 3.9 |
| 2 | 4.3 | 5.1 | 5.3 | 7.25 | 5.0 | 8.0 | 3.6 | 2.7 | 2.8 | 2.9 | 3.2 | 3.9 |
| 3 | 4.1 | 5.0 | 5.2 | 7.0 | 4.9 | 7.4 | 3.5 | 2.7 | 2.8 | 3.0 | 3.2 | 3.9 |
| 4 | 4.1 | 4.8 | 5.2 | 7.1 | 4.9 | 7.4 | 3.5 | 2.7 | 2.8 | 3.0 | 3.1 | 3.9 |
| 5 | 4.1 | 4.6 | 5.1 | 7.2 | 4.7 | 7.3 | 3.4 | 2.7 | 2.8 | 3.0 | 3.2 | 3.9 |
| 6 | 4.2 | 4.5 | 5.0 | 7.2 | 4.7 | 7.2 | 3.3 | 2.7 | 2.8 | 3.0 | 3.2 | 4.0 |
| 7 | 4.6 | 4.5 | 4.9 | 7.2 | 4.5 | 6.9 | 3.3 | 2.7 | 2.8 | 3.0 | 3.2 | 4.3 |
| 8 | 4.6 | 4.4 | 5.1 | 7.2 | 4.4 | 6.7 | 3.2 | 2.7 | 2.8 | 3.0 | 3.3 | 4.6 |
| 9 | 4.04 | 4.4 | 5.5 | 7.3 | 4.4 | 6.5 | 3.1 | 2.7 | 2.8 | 3.0 | 3.5 | 4.8 |
| 10 | 4.2 | 4.3 | 5.7 | 6.8 | 4.3 | 6.2 | 3.1 | 2.7 | 2.8 | 3.0 | 3.5 | 4.8 |
| 11 | 4.3 | 4.3 | 5.8 | 6.5 | 4.3 | 5.7 | 3.1 | 2.7 | 2.8 | 3.0 | 3.5 | 4.8 |
| 12 | 4.3 | 4.2 | 5.5 | 6.1 | 4.2 | 5.4 | 3.1 | 2.8 | 2.8 | 3.0 | 3.5 | 4.7 |
| 13 | 4.3 | 4.1 | 5.5 | 6.0 | 4.2 | 5.0 | 3.1 | 3.0 | 3.0 | 3.0 | 3.5 | 4.6 |
| 14 | 4.3 | 4.1 | 5.2 | 6.0 | 4.2 | 4.9 | 3.1 | 3.0 | 3.1 | 3.0 | 5.2 | 4.5 |
| 15 | 4.2 | 4.0 | 5.1 | 6.1 | 4.2 | 4.8 | 3.0 | 3.0 | 3.1 | 3.0 | 5.9 | 4.5 |
| 16 | 4.2 | 4.0 | 5.0 | 6.4 | 4.2 | 4.8 | 3.0 | 3.0 | 3.1 | 3.5 | 5.7 | 4.5 |
| 17 | 4.3 | 4.0 | 4.9 | 6.3 | 4.0 | 4.6 | 3.0 | 3.0 | 3.0 | 3.5 | 5.0 | 4.4 |
| 18 | 4.3 | 4.0 | 4.5 | 6.1 | 4.0 | 4.5 | 3.0 | 2.9 | 3.0 | 3.5 | 4.9 | 4.4 |
| 19 | 4.3 | 5.0 | 4.6 | 6.0 | 3.9 | 4.5 | 3.0 | 2.9 | 3.0 | 3.5 | 4.5 | 4.5 |
| 20 | 4.3 | 5.8 | 4.6 | 6.0 | 3.9 | 4.4 | 2.9 | 2.8 | 3.0 | 3.5 | 4.5 | 6.8 |
| 21 | 4.2 | 5.7 | 4.6 | 6.2 | 3.9 | 4.3 | 2.9 | 2.8 | 3.0 | 3.5 | 4.5 | 9.0 |
| 22 | 4.2 | 5.7 | 4.7 | 6.4 | 3.9 | 4.3 | 2.9 | 2.8 | 3.0 | 3.5 | 4.4 | 7.8 |
| 23 | 4.3 | 5.6 | 4.7 | 6.3 | 3.9 | 4.2 | 2.8 | 2.8 | 2.9 | 3.6 | 4.3 | 7.0 |
| 24 | 4.8 | 5.6 | 5.9 | 5.9 | 3.9 | 4.2 | 2.8 | 2.8 | 2.9 | 3.6 | 4.3 | 6.5 |
| 25 | 5.3 | 5.5 | 6.1 | 5.7 | 3.9 | 4.1 | 2.8 | 3.0 | 2.9 | 3.6 | 4.2 | 6.5 |
| 26 | 5.8 | 5.4 | 6.7 | 5.45 | 3.9 | 4.0 | 2.7 | 2.9 | 2.9 | 3.6 | 4.0 | 7.0 |
| 27 | 5.7 | 5.3 | 7.2 | 5.3 | 3.8 | 4.0 | 2.7 | 2.9 | 2.9 | 3.6 | 4.0 | 7.1 |
| 28 | 5.6 | 5.3 | 7.4 | 5.3 | 4.0 | 4.1 | 2.7 | 2.8 | 2.9 | 3.5 | 4.0 | 6.5 |
| 29 | 5.4 | ..... | 7.0 | 5.2 | 6.65 | 3.9 | 2.7 | 2.8 | 2.9 | 3.4 | 4.0 | 6.4 |
| 30 | 5.4 | ..... | 7.2 | 5.2 | [a]15.0 | 3.8 | 2.7 | 2.8 | 2.9 | 3.3 | 4.0 | 6.4 |
| 31 | 5.3 | ..... | 7.75 | ..... | 13.0 | ..... | 2.7 | 2.8 | ..... | 3.3 | ..... | 6.4 |

[a] Estimated; water overflowed bottom lands.

*Rating table for Umatilla River at Yoakum, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.70 | 28 | 3.80 | 225 | 4.90 | 755 | 6.00 | 1,645 | 8.20 | 4,590 |
| 2.80 | 37 | 3.90 | 253 | 5.00 | 820 | 6.20 | 1,840 | 8.40 | 4,940 |
| 2.90 | 47 | 4.00 | 284 | 5.10 | 890 | 6.40 | 2,040 | 8.60 | 5,300 |
| 3.00 | 59 | 4.10 | 320 | 5.20 | 965 | 6.60 | 2,260 | 8.80 | 5,680 |
| 3.10 | 73 | 4.20 | 360 | 5.30 | 1,040 | 6.80 | 2,500 | 9.00 | 6,060 |
| 3.20 | 89 | 4.30 | 410 | 5.40 | 1,120 | 7.00 | 2,750 | 10.00 | 8,190 |
| 3.30 | 107 | 4.40 | 460 | 5.50 | 1,200 | 7.20 | 3,020 | 11.00 | 10,750 |
| 3.40 | 127 | 4.50 | 515 | 5.60 | 1,285 | 7.40 | 3,310 | 12.00 | 13,730 |
| 3.50 | 149 | 4.60 | 570 | 5.70 | 1,370 | 7.60 | 3,610 | 13.00 | 17,000 |
| 3.60 | 173 | 4.70 | 630 | 5.80 | 1,460 | 7.80 | 3,930 | 14.00 | 20,400 |
| 3.70 | 199 | 4.80 | 690 | 5.90 | 1,550 | 8.00 | 4,250 | 15.00 | 23,900 |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1906 and is well defined below gage height 9.7 feet.

*Monthly discharge of Umatilla River at Yoakum, Oreg., for 1906.*

[Drainage area, 1,200 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 1,460 | 298 | 587 | 36,100 | 0.489 | 0.56 |
| February | 1,460 | 284 | 697 | 38,700 | .581 | .60 |
| March | 3,850 | 515 | 1,370 | 84,200 | 1.14 | 1.31 |
| April | 4,340 | 965 | 2,090 | 124,000 | 1.74 | 1.94 |
| May | 23,900 | 225 | 1,770 | 109,000 | 1.47 | 1.70 |
| June | 7,080 | 225 | 1,460 | 86,900 | 1.22 | 1.36 |
| July | 199 | 28 | 72.7 | 4,470 | .061 | .07 |
| August | 59 | 28 | 39.4 | 2,420 | .033 | .04 |
| September | 73 | 37 | 48.4 | 2,880 | .040 | .04 |
| October | 173 | 47 | 105 | 6,460 | .088 | .10 |
| November | 1,550 | 73 | 384 | 22,800 | .320 | 0.36 |
| December | 6,060 | 253 | 1,360 | 83,600 | 1.13 | 1.30 |
| The year | 23,900 | 28 | 832 | 602,000 | .693 | 9.38 |

NOTE.—Values are rated as follows: January, February, and July to November, good; March to June and December, excellent.

## UMATILLA RIVER AT UMATILLA, OREG.

This station was established October 21, 1903. It is located about 1 mile above Umatilla, Oreg., and about one-fourth mile below the diversion dam of the Oregon Land and Water Company. To obtain the total discharge of the river, the discharge of the irrigation ditch must be added to that of the river at the gage. The gage was read during 1906 by N. E. Newton. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 188, where are given also references to publications that contain data for previous years.

*Discharge measurements of Umatilla River at Umatilla, Oreg., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| December 20 | R. S. Hall | 167 | 165 | 3.08 | 363 |
| 1906. | | | | | |
| February 22 | R. S. Hall | 177 | 328 | 4.00 | 1,330 |
| March 17 | do | 174 | 219 | 3.40 | 652 |
| April 19 | J. C. Stevens | 176 | 328 | 4.05 | 1,440 |
| May 28 | R. S. Hall | 154 | 105 | 2.70 | 169 |
| May 31 [a] | Stevens and Lewis | | 1,620 | 11.00 | 17,500 |
| June 11 | R. S. Hall | 176 | 330 | 4.05 | 1,360 |
| June 23 | do | 165 | 178 | 3.02 | 414 |
| August 11 [b] | J. C. Stevens | | | 1.10 | 0.3 |
| November 25 | H. McGlashan | 165 | 163 | 3.00 | 348 |

[a] Measured by floats. [b] Stream bed dry except at left edge.

*Daily gage height, in feet, of Umatilla River at Umatilla, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.9 | | | 5.4 | 3.5 | 8.0 | 2.65 | 1.0 | 1.2 | 1.8 | 2.3 | 2.8 |
| 2 | | 3.4 | 3.8 | | | 6.3 | | | | 2.1 | 2.3 | |
| 3 | 2.8 | | | 4.9 | 3.4 | 5.5 | 2.5 | 1.0 | 1.2 | 2.15 | 2.25 | 2.75 |
| 4 | | 3.35 | 3.6 | | | | | | | 2.1 | 2.3 | |
| 5 | 2.8 | | | 4.7 | 3.3 | 5.4 | 2.25 | 1.0 | 1.2 | 2.0 | 2.3 | 2.7 |
| 6 | | 3.3 | 3.5 | | | | | | | 2.0 | 2.35 | |
| 7 | 3.0 | | | 4.7 | 3.15 | 5.0 | 2.0 | 1.0 | 1.2 | 2.1 | 2.4 | 2.7 |
| 8 | | 3.25 | 3.4 | | | | | | | 2.1 | 2.4 | |
| 9 | 3.25 | | | 4.8 | 3.05 | 4.5 | 1.75 | 1.0 | 1.2 | 2.1 | 2.4 | 3.1 |
| 10 | | 3.2 | 3.7 | | | | | | | 2.1 | 2.6 | |
| 11 | 3.2 | | | 4.6 | 2.9 | 4.1 | 1.7 | 1.1 | 1.2 | 2.1 | 2.6 | 3.2 |
| 12 | | 3.0 | 3.7 | | | | | | | 2.1 | 2.6 | |
| 13 | 3.1 | | | 4.2 | 2.85 | 3.8 | 1.6 | 1.1 | 1.25 | 2.1 | 2.6 | 3.3 |
| 14 | | 2.95 | 3.9 | | | | | | | 2.2 | 2.6 | |
| 15 | 3.1 | | | 4.0 | 2.9 | 3.5 | 1.3 | 1.1 | 1.3 | 2.2 | 3.9 | 3.3 |
| 16 | | 2.9 | 3.6 | | | 3.7 | | | | 2.15 | 3.8 | |
| 17 | 3.1 | | | 4.2 | 2.85 | 3.6 | 1.2 | 1.1 | 1.8 | 2.2 | 3.7 | 3.2 |
| 18 | | 3.0 | 3.3 | | | | | | | 2.2 | 3.6 | 3.15 |
| 19 | 3.0 | | | 4.1 | 2.7 | 3.3 | 1.1 | 1.1 | 1.9 | 2.2 | 3.4 | 3.1 |
| 20 | | 3.5 | 3.2 | | | | | | | 2.3 | 3.3 | 3.0 |
| 21 | 3.0 | | | 4.0 | 2.65 | 3.15 | 1.1 | 1.1 | 1.85 | 2.3 | 3.2 | 5.2 |
| 22 | | 4.1 | 3.2 | | | | | | | 2.25 | 3.1 | 6.1 |
| 23 | 3.0 | | | 4.1 | 2.7 | 3.0 | 1.1 | 1.1 | 1.85 | 2.25 | 3.1 | 5.2 |
| 24 | | 3.9 | 3.2 | | | | | | | 2.3 | 3.0 | 4.7 |
| 25 | 3.6 | | | 3.9 | 2.6 | 2.9 | 1.0 | 1.2 | 1.85 | 2.3 | 3.0 | 4.5 |
| 26 | | 3.8 | 4.2 | | | | | | | 2.3 | 2.95 | 4.6 |
| 27 | 3.85 | | | 3.7 | 2.6 | 2.7 | 1.1 | 1.2 | 1.8 | 2.3 | 2.9 | 4.9 |
| 28 | | 3.7 | 4.8 | | 2.7 | | | | | 2.3 | 2.9 | 4.65 |
| 29 | 3.6 | | | 3.6 | 2.8 | 2.8 | 1.1 | 1.2 | 1.8 | 2.35 | 2.9 | 4.45 |
| 30 | | | 4.7 | | 6.85 | | | | | 2.4 | 2.85 | 4.3 |
| 31 | 3.5 | | | | 10.2 | | 1.1 | 1.2 | | 2.35 | | 4.3 |

*Rating table for Umatilla River at Umatilla, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.10 | 0.1 | 2.10 | 21 | 3.10 | 400 | 4.20 | 1,670 | 6.20 | 5,220 |
| 1.20 | .2 | 2.20 | 32 | 3.20 | 485 | 4.40 | 1,975 | 6.40 | 5,620 |
| 1.30 | .3 | 2.30 | 45 | 3.30 | 575 | 4.60 | 2,290 | 6.60 | 6,030 |
| 1.40 | .4 | 2.40 | 60 | 3.40 | 675 | 4.80 | 2,620 | 6.80 | 6,450 |
| 1.50 | .5 | 2.50 | 80 | 3.50 | 775 | 5.00 | 2,960 | 7.00 | 6,880 |
| 1.60 | .7 | 2.60 | 108 | 3.60 | 885 | 5.20 | 3,310 | 8.00 | 9,200 |
| 1.70 | 1.5 | 2.70 | 146 | 3.70 | 1,000 | 5.40 | 3,675 | 9.00 | 11,800 |
| 1.80 | 3.5 | 2.80 | 194 | 3.80 | 1,125 | 5.60 | 4,050 | 10.00 | 14,580 |
| 1.90 | 7.5 | 2.90 | 252 | 3.90 | 1,250 | 5.80 | 4,435 | 11.00 | 17,500 |
| 2.00 | 13 | 3.00 | 320 | 4.00 | 1,385 | 6.00 | 4,825 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903–1906 and is well defined between gage heights 2 feet and 7 feet.

*Monthly discharge of Umatilla River at Umatilla, Oreg., for 1906.*

[Drainage area, 2,130 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 1,190 | 194 | 492 | 30,300 | 0.231 | 0.27 |
| February | 1,520 | 252 | 691 | 38,400 | .324 | .34 |
| March | 3,070 | 485 | 1,130 | 69,500 | .531 | .61 |
| April | 3,680 | 830 | 1,860 | 111,000 | .873 | .97 |
| May | 15,200 | 108 | 983 | 60,400 | .462 | .53 |
| June | 9,200 | 146 | 1,690 | 101,000 | .793 | .88 |
| July | 127 | 0 | 15.0 | 922 | .007 | .01 |
| August | 0.2 | 0 | .094 | 5.8 | .000044 | .00005 |
| September | 7.5 | 0.2 | 2.46 | 146 | .0012 | .001 |
| October | 60 | 3.5 | 31.9 | 1,960 | .015 | .02 |
| November | 1,250 | 38.5 | 323 | 19,200 | .152 | .17 |
| December | 5,020 | 146 | 1,180 | 72,600 | .554 | .64 |
| The year | 15,200 | 0 | 700 | 505,000 | .329 | 4.45 |

NOTE.—Values are rated as follows: January to June, November and December, excellent; July and October, fair; August and September, approximate. Discharges interpolated for days on which gage heights were not observed.

## MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in Umatilla River drainage basin during 1906:

*Meacham Creek at Gibbon, Oreg.*—A measurement was made from the highway bridge one-half mile east of the Bingham Springs railroad station February 1, 1906. The water surface was 8.72 feet below the lower end of the floor plank, 5.3 feet from the left end of the truss.

Width, 45 feet; area, 130 square feet; discharge, 189 second-feet.

*Minnehaha Spring near Hermiston, Oreg.*—The following measurement was made May 7, 1906:

Width, 6 feet; area, 2.7 feet; discharge, 2.6 second-feet.

*Wild Horse Creek near Pendleton, Oreg.*—A measurement was made February 26, 1906. The water surface was 7.42 feet below a tack in the upstream side of the bridge.

Width, 16 feet; area, 13 square feet; discharge, 22 second-feet.

*Discharge measurements of Umatilla River near Fosters,[a] Oreg., in 1905–6.*

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| 1905. | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| November 11 | 66 | 55 | 1.08 | 40 |
| December 4 | 82 | 106 | 1.78 | 227 |
| December 22 | 115 | 159 | 2.10 | 413 |
| December 28 | 102 | 124 | 1.84 | 291 |
| 1906. | | | | |
| January 5 | 100 | 115 | 1.80 | 219 |
| January 13 | 116 | 157 | 2.18 | 420 |
| January 17 | 116 | 166 | 2.18 | 429 |
| January 29 | 138 | 267 | 2.90 | 1,090 |
| February 9 | 117 | 161 | 2.12 | 423 |
| February 17 | 105 | 129 | 1.85 | 284 |
| March 2 | 138 | 272 | 2.95 | 1,140 |

[a] At highway bridge, 4 miles below Echo, Oreg.

*Discharge measurements of Umatilla River at Pendleton, Oreg., in 1906.*

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 31 [a] | 89 | 297 | ..... | 582 |
| February 3 [b] | 104 | 144 | 4.48 | 540 |
| February 14 [a] | 82 | 246 | 4.20 | 253 |
| February 26 [b] | 115 | 196 | 4.78 | 903 |
| March 21 [a] | 85 | 254 | 4.28 | 317 |

[a] From Oregon Railroad and Navigation Company's railway bridge.
[b] From highway bridge.

## CANALS IN UMATILLA RIVER VALLEY, OREGON.

The points of diversion of these canals and the points of measurement are described in Water-Supply Paper No. 178, pages 190 to 201, where are also given the data collected during 1905.

*Discharge measurements of canals in Umatilla River Valley, Oregon, in 1906.*

HORSESHOE IRRIGATION COMPANY'S CANAL, YOAKUM.

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| March 3 | 4 | 2 | ..... | 2.5 |
| May 4 | 3.4 | 1.4 | ..... | .87 |

SLUSHER AND GOULD CANAL, NOLIN.

| | | | | |
|---|---|---|---|---|
| January 6 | 4.2 | 3.5 | 0.77 | 2.0 |
| March 3 | 4.1 | 1.6 | .42 | .9 |

CHARLES LISLE CANAL, ECHO.

| | | | | |
|---|---|---|---|---|
| January 6 | 7.6 | 6.9 | 0.99 | 1.9 |
| January 17 | 7.7 | 7.0 | .94 | 1.8 |
| February 8 | 7.3 | 5.8 | .82 | 1.8 |
| February 17 | 9.8 | 9.2 | 1.24 | .94 |
| May 4 | 8.2 | 6.9 | .98 | 3.85 |

MILL CANAL, ECHO.

| | | | | |
|---|---|---|---|---|
| January 6 | 9.4 | 7.1 | 1.58 | 5.2 |
| January 13 | 9.7 | 7.9 | 1.67 | 6.6 |
| January 17 | 9.8 | 8.0 | 1.58 | 7.0 |
| February 8 | 5.9 | 1.7 | .89 | .56 |
| February 17 | 7.3 | 4.6 | 1.40 | 4.0 |
| March 3 | 8.0 | 7.2 | 1.82 | 7.8 |
| May 4 | 5.5 | 1.9 | .99 | 1.3 |

MILL CANAL WASTEWAY, ECHO.

| | | | | |
|---|---|---|---|---|
| 1905. | | | | |
| December 28 | 7.0 | 5.2 | 1.10 | 3.8 |
| 1906. | | | | |
| January 6 | 7.0 | 5.8 | 1.13 | 4.3 |
| January 17 | 7.2 | 7.0 | 1.20 | 5.0 |
| February 8 | 4.8 | 1.4 | .34 | 0.18 |
| February 17 | 6.7 | 5.02 | .92 | 4.86 |
| March 2 | 7.2 | 7.4 | 1.20 | 7.5 |

*Discharge measurements of canals in Umatilla River Valley, Oregon, in 1906*—Cont'd.

WILSON & CO.'S CANAL, ECHO.

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 8 | 7.6 | 4.6 | 2.72 | 4.2 |
| May 4 | 7.1 | 3.2 | 1.58 | 2.6 |

ALLEN CANAL, ECHO.

| | | | | |
|---|---|---|---|---|
| 1905. | | | | |
| December 28 | 10.2 | 16 | 1.24 | 14 |
| 1906. | | | | |
| January 5 | 10.2 | 16 | 1.25 | 13 |
| January 17 | 10.3 | 16 | 1.25 | 12 |
| March 2 | 9.7 | 6.9 | ..... | 2.8 |
| May 5 | 10.7 | 17 | 1.15 | 29 |

ALLEN CANAL WASTEWAY, ECHO.

| | | | | |
|---|---|---|---|---|
| January 5 | 5.2 | 4.7 | 0.75 | 7.3 |
| January 17[a] | 5.5 | 6.0 | ..... | 10 |
| February 9 | 5.2 | 3.7 | .52 | 3.14 |
| February 17 | 3.6 | 2.2 | .30 | .47 |
| March 2 | 3.5 | 2.4 | .28 | .44 |
| May 5 | 3.6 | 2.5 | .29 | .7 |

HINKLE CANAL, ECHO.

| | | | | |
|---|---|---|---|---|
| January 5 | 14 | 14 | 1.70 | 14 |
| January 13 | 13.8 | 14 | 1.70 | 15 |
| January 17 | 14.4 | 14 | 1.71 | 15 |
| February 8 | 15 | 16 | 1.91 | 20 |
| February 17 | 12 | 11 | 1.50 | 9.3 |
| March 2 | 12.7 | 13 | 1.73 | 14 |
| May 5 | 16 | 25 | 2.43 | 42 |

PIONEER CANAL, ECHO.

| | | | | |
|---|---|---|---|---|
| January 5 | 8.2 | 3.4 | 0.80 | 2.2 |
| January 17 | 9.7 | 5.1 | .98 | 4.33 |
| May 5 | 12.4 | 23 | 1.58 | 54 |

HERMISTON CANAL, HERMISTON.

| | | | | |
|---|---|---|---|---|
| 1905. | | | | |
| December 28 | 15.3 | 14 | ..... | 11 |
| 1906. | | | | |
| January 15[b] | 15.4 | 15 | ..... | 11 |
| February 16[c] | 16.0 | 17 | 0.62 | 17 |
| May 7 | 19.0 | 29 | 1.34 | 39 |

BEITLE CANAL, HERMISTON.

| | | | | |
|---|---|---|---|---|
| May 7 | 3.7 | 1.8 | 0.92 | 1.4 |

OREGON LAND AND WATER COMPANYS CANAL, UMATILLA.

| | | | | |
|---|---|---|---|---|
| May 7 | 13.5 | 19 | ..... | 44 |
| November 25 | 4.8 | 4.1 | ..... | 13 |

[a] Measured above wasteway. [b] At headgate. [c] Below headgate.

*Discharge measursmente of canals in Umatilla River Valley, Oregon, in 1906.*—Cont'd.

BROWNELL CANAL, HERMISTON.

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| 1905. | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| December 29 | 5 | 2.8 | 0.98 | 0.97 |
| 1906. | | | | |
| January 15 | 5 | 4.3 | 1.72 | 4.0 |
| May 7 | 5 | 6.4 | 1.58 | 10 |

MAXWELL CANAL, ECHO.

| | | | | |
|---|---|---|---|---|
| January 5 | 5.2 | 1.6 | 0.31 | 0.79 |
| January 15 | 5.4 | 2.0 | .30 | 1.0 |
| May 3 | 10.4 | 8.4 | ..... | 15 |

## WILLOW CREEK DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

This stream rises in the timbered foothills of the Blue Mountains and flows northwestward into Columbia River near Arlington. Its drainage area throughout is timberless, and is composed of high, rolling table-lands used for the production of wheat and as range for cattle and sheep. The creek is small but is subject to excessive and sudden floods. In 1903 this stream was the scene of the disaster at Heppner, where over one hundred lives were lost from a sudden flood lasting scarcely more than an hour. The waters of this stream are used to some extent for irrigation in the immediate valley.

### WILLOW CREEK NEAR ARLINGTON, OREG.

This station was established December 17, 1904, and was abandoned July 21, 1906, on account of poor conditions. It is located at the wagon bridge at Rhea siding, 9 miles from Arlington, Oreg. The station was maintained as a flood station and miscellaneous measurements only are made during the summer season.

During 1906 the gage was read by G. R. Huff. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 202.

*Discharge measurements of Willow Creek near Arlington, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 7 | F. C. Dillard | 24 | 85 | (a) | 33 |
| February 28 | R. S. Hall | 23.5 | 51 | 1.50 | 55 |
| March 31 | F. C. Dillard | 26 | 107 | (a) | 207 |
| April 19 | J. C. Stevens | 23.5 | 41 | 1.12 | 32 |
| June 9 | R. S. Hall | 24.5 | 89 | 3.15 | 296 |
| June 9 | ....do | 24 | 94 | 3.40 | 363 |

a Gage not read.

*Daily gage height, in feet, of Willow Creek near Arlington, Oreg., for 1906.*

| Day. | Mar. | Apr. | May. | June. | July. | Day. | Mar. | Apr. | May. | June. | July. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.52 | 2.8 | 0.85 | 4.4 | 1.15 | 17 | 1.35 | 1.25 | 0.45 | 2.4 | 0.8 |
| 2 | 1.52 | 2.7 | .8 | 3.9 | 1.1 | 18 | 1.6 | 1.2 | .45 | 2.2 | .8 |
| 3 | 1.5 | 2.5 | .75 | 3.65 | 1.0 | 19 | 1.5 | 1.15 | .45 | 2.0 | .8 |
| 4 | 1.52 | 2.4 | .65 | 3.9 | .95 | 20 | 1.45 | 1.1 | .45 | 1.9 | .8 |
| 5 | 1.55 | 2.3 | .6 | 4.05 | .95 | 21 | 1.4 | 1.1 | .45 | 1.8 | .8 |
| 6 | 1.5 | 2.2 | .6 | 3.75 | .95 | 22 | 1.98 | 1.1 | .45 | 1.6 | ..... |
| 7 | 1.52 | 2.1 | .6 | 3.5 | .95 | 23 | 2.45 | 1.1 | .45 | 1.5 | ..... |
| 8 | 1.62 | 2.0 | .6 | 3.2 | .9 | 24 | 2.3 | 1.1 | .45 | 1.4 | ..... |
| 9 | 1.75 | 1.9 | .55 | 3.0 | .85 | 25 | 2.4 | 1.1 | .5 | 1.35 | ..... |
| 10 | 1.8 | 1.8 | .5 | 3.1 | .85 | 26 | 4.15 | 1.1 | .5 | 1.25 | ..... |
| 11 | 1.8 | 1.7 | .5 | 2.8 | .9 | 27 | 3.0 | 1.0 | .6 | 1.2 | ..... |
| 12 | 1.75 | 1.6 | .45 | 2.6 | .9 | 28 | 3.1 | 1.0 | .55 | 1.2 | ..... |
| 13 | 1.8 | 1.5 | .45 | 2.6 | .9 | 29 | 2.7 | .9 | .5 | 1.2 | ..... |
| 14 | 1.8 | 1.4 | .45 | 2.45 | .85 | 30 | 2.4 | .9 | 6.7 | 1.15 | ..... |
| 15 | 1.75 | 1.35 | .4 | 2.3 | .8 | 31 | 2.4 | ..... | 6.0 | ..... | ..... |
| 16 | 1.35 | 1.3 | .45 | 3.1 | .8 | | | | | | |

NOTE.—Some ice March 12 and 13; discharge not corrected.

*Rating table for Willow Creek near Arlington, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.40 | 10 | 1.20 | 35 | 2.00 | 100 | 2.80 | 224 | 3.60 | 421 |
| 0.50 | 12 | 1.30 | 41 | 2.10 | 112 | 2.90 | 244 | 3.70 | 454 |
| 0.60 | 14 | 1.40 | 48 | 2.20 | 125 | 3.00 | 265 | 3.80 | 489 |
| 0.70 | 16 | 1.50 | 55 | 2.30 | 139 | 3.10 | 286 | 3.90 | 526 |
| 0.80 | 19 | 1.60 | 63 | 2.40 | 154 | 3.20 | 309 | 4.00 | 565 |
| 0.90 | 22 | 1.70 | 72 | 2.50 | 170 | 3.30 | 334 | 5.00 | 965 |
| 1.00 | 25 | 1.80 | 81 | 2.60 | 187 | 3.40 | 361 | 6.00 | 1,365 |
| 1.10 | 30 | 1.90 | 90 | 2.70 | 205 | 3.50 | 390 | 7.00 | 1,765 |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 4 discharge measurements made during 1906 and is not well defined.

*Monthly discharge of Willow Creek near Arlington, Oreg., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| March | 625 | 44 | 115 | 7,070 |
| April | 224 | 22 | 71.1 | 4,230 |
| May | 1,640 | 10 | 109 | 6,700 |
| June | 725 | 32 | 221 | 13,200 |
| July 1–21 | 32 | 19 | 22.1 | 920 |
| The period | ..... | ..... | ..... | 32,100 |

NOTE.—Values are rated as follows: May, approximate; remainder of period, fair.

## JOHN DAY RIVER DRAINAGE BASIN.

### JOHN DAY RIVER AT M'DONALD, OREG.

John Day River rises in the Blue Mountains in northeastern Oregon, at an elevation of about 5,000 feet, and flows northward into Columbia River. The lower 90 miles of the stream flows in a comparatively deep canyon from which it is impracticable to take water for irrigation. The surrounding country is rolling, timberless land, partly cultivated and partly desert. The upper portions of the stream are more broken and mountainous, and large areas are well timbered. The river is fed by innumerable tributaries draining timbered mountain slopes. The main stream is formed by the junction of three

important streams called North, Middle, and South forks of John Day River. The rainfall in the drainage area varies from 25 inches on the headwaters to 9 inches at the mouth of the river.

The waters of the numerous mountain tributaries are used extensively for irrigating small valleys, for mining, and for power purposes. Irrigation is not practiced in the lower portion of the stream to any considerable extent.

This station was established November 14, 1901. It is located at the ferry at McDonald, 16 miles above the mouth of the river and 18 miles southwest of Arlington, Oreg. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 203, where are given also references to publications that contain data for previous years.

*Discharge measurements of John Day River at McDonald, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| February 6 | F. C. Dillard | 263 | 728 | 2.35 | 866 |
| February 23 | R. S. Hall | 282 | 1,140 | 3.88 | 2,990 |
| March 15 | do | 273 | 910 | 3.10 | 1,710 |
| April 2 | F. C. Dillard | 319 | 2,050 | 6.70 | 10,500 |
| April 17 | J. C. Stevens | 314 | 1,640 | 5.50 | 6,840 |
| May 2 | R. S. Hall | 309 | 1,430 | 4.70 | 4,760 |
| June 8 | do | 322 | 1,860 | 6.16 | 8,670 |
| July 6 | do | 278 | 797 | 2.69 | 1,240 |
| November 23 | H. McGlashan | 268 | 624 | 1.97 | 495 |

*Daily gage height, in feet, of John Day River at McDonald, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.80 | 2.40 | 3.80 | 7.50 | 4.70 | 6.98 | 3.22 | 1.55 | 1.45 | 1.55 | 1.75 | 1.70 |
| 2 | 1.90 | 2.52 | 3.55 | 6.72 | 4.68 | 6.48 | 3.08 | 1.55 | 1.45 | 1.55 | 1.75 | 1.80 |
| 3 | 1.85 | 2.58 | 3.25 | 6.05 | 4.62 | 6.20 | 2.98 | 1.55 | 1.40 | 1.55 | 1.75 | 1.80 |
| 4 | 1.78 | 2.42 | 3.15 | 5.45 | 4.58 | 6.10 | 2.88 | 1.50 | 1.40 | 1.55 | 1.75 | 1.85 |
| 5 | 1.80 | 2.42 | 3.10 | 5.35 | 4.52 | 6.78 | 2.78 | 1.50 | 1.40 | 1.55 | 1.75 | 1.85 |
| 6 | 1.85 | 2.35 | 3.10 | 5.45 | 4.55 | 6.82 | 2.68 | 1.50 | 1.40 | 1.55 | 1.75 | 1.92 |
| 7 | 1.88 | 2.35 | 3.05 | 5.60 | 4.35 | 6.55 | 2.60 | 1.50 | 1.40 | 1.55 | 1.72 | 1.95 |
| 8 | 1.90 | 2.30 | 3.15 | 6.00 | 4.15 | 6.15 | 2.50 | 1.50 | 1.40 | 1.55 | 1.82 | 2.00 |
| 9 | 1.85 | 2.20 | 3.75 | 5.92 | 4.05 | 5.80 | 2.48 | 1.45 | 1.40 | 1.60 | 1.85 | 2.00 |
| 10 | 1.90 | 2.15 | 4.15 | 5.90 | 3.98 | 5.70 | 2.42 | 1.45 | 1.35 | 1.60 | 1.85 | 2.10 |
| 11 | 1.90 | 2.20 | 4.50 | 5.85 | 3.92 | 5.45 | 2.42 | 1.45 | 1.35 | 1.60 | 1.85 | 2.20 |
| 12 | 1.90 | 2.18 | 4.25 | 5.55 | 3.98 | 5.25 | 2.32 | 1.45 | 1.40 | 1.60 | 1.92 | 2.20 |
| 13 | 1.88 | 2.12 | 4.75 | 5.25 | 3.98 | 5.05 | 2.28 | 1.45 | 1.40 | 1.60 | 2.00 | 2.15 |
| 14 | 1.90 | 2.12 | 3.40 | 5.05 | 4.00 | 4.95 | 2.20 | 1.40 | 1.45 | 1.60 | 1.95 | 2.18 |
| 15 | 1.90 | 2.20 | 3.15 | 5.00 | 3.80 | 4.72 | 2.12 | 1.82 | 1.45 | 1.60 | 2.00 | 2.28 |
| 16 | 2.00 | 2.20 | 3.10 | 5.12 | 3.70 | 4.55 | 2.05 | 1.88 | 1.45 | 1.60 | 1.95 | 2.20 |
| 17 | 2.00 | 2.20 | 3.00 | 5.35 | 3.80 | 4.60 | 2.00 | 1.70 | 1.52 | 1.60 | 2.00 | 2.15 |
| 18 | 2.10 | 2.28 | 2.90 | 5.60 | 3.65 | 4.72 | 2.00 | 1.65 | 1.65 | 1.60 | 2.40 | 2.10 |
| 19 | 2.30 | 2.30 | 2.95 | 5.35 | 3.50 | 4.50 | 1.92 | 1.60 | 1.75 | 1.65 | 2.30 | 2.00 |
| 20 | 2.18 | 3.35 | 3.00 | 5.12 | 3.40 | 4.15 | 1.90 | 1.60 | 1.75 | 1.65 | 2.22 | 2.10 |
| 21 | 2.10 | 3.88 | 3.00 | 5.10 | 3.28 | 4.00 | 1.90 | 1.50 | 1.70 | 1.70 | 2.20 | 2.10 |
| 22 | 2.05 | 3.70 | 3.00 | 5.25 | 3.25 | 3.88 | 1.85 | 1.50 | 1.70 | 1.70 | 2.10 | 2.20 |
| 23 | 2.00 | 3.85 | 3.35 | 5.60 | 3.30 | 3.78 | 1.80 | 1.50 | 1.70 | 1.70 | 2.00 | 2.25 |
| 24 | 2.25 | 3.50 | 4.55 | 5.60 | 3.40 | 3.60 | 1.80 | 1.45 | 1.65 | 1.70 | 2.00 | 2.55 |
| 25 | 2.60 | 3.25 | 5.05 | 5.50 | 3.40 | 3.50 | 1.75 | 1.45 | 1.60 | 1.75 | 2.10 | 2.68 |
| 26 | 2.95 | 3.20 | 6.55 | 5.35 | 3.30 | 3.40 | 1.70 | 1.45 | 1.60 | 1.75 | 2.00 | 2.75 |
| 27 | 2.92 | 3.10 | 6.40 | 5.22 | 3.40 | 3.45 | 1.70 | 1.45 | 1.60 | 1.75 | 1.95 | 3.60 |
| 28 | 2.80 | 3.10 | 6.55 | 5.00 | 3.40 | 3.30 | 1.65 | 1.48 | 1.60 | 1.75 | 1.90 | 4.10 |
| 29 | 2.58 | ..... | 6.30 | 4.85 | 3.50 | 3.35 | 1.60 | 1.50 | 1.60 | 1.75 | 1.95 | 3.75 |
| 30 | 2.50 | ..... | 6.10 | 4.72 | 3.50 | 3.40 | 1.60 | 1.50 | 1.60 | 1.75 | 1.90 | 3.45 |
| 31 | 2.42 | ..... | 6.50 | ..... | 7.85 | ..... | 1.60 | 1.50 | ..... | 1.75 | ..... | 3.25 |

*Rating table for John Day River at McDonald, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.00 | 60 | 2.00 | 540 | 3.00 | 1,615 | 3.90 | 3,050 | 5.60 | 7,050 |
| 1.10 | 85 | 2.10 | 625 | 3.10 | 1,750 | 4.00 | 3,240 | 5.80 | 7,590 |
| 1.20 | 115 | 2.20 | 715 | 3.20 | 1,890 | 4.20 | 3,650 | 6.00 | 8,150 |
| 1.30 | 145 | 2.30 | 810 | 3.30 | 2,035 | 4.40 | 4,090 | 6.20 | 8,710 |
| 1.40 | 180 | 2.40 | 910 | 3.40 | 2,185 | 4.60 | 4,550 | 6.40 | 9,290 |
| 1.50 | 220 | 2.50 | 1,015 | 3.50 | 2,345 | 4.80 | 5,020 | 6.60 | 9,880 |
| 1.60 | 265 | 2.60 | 1,125 | 3.60 | 2,515 | 5.00 | 5,500 | 6.80 | 10,480 |
| 1.70 | 320 | 2.70 | 1,240 | 3.70 | 2,690 | 5.20 | 6,000 | 7.00 | 11,100 |
| 1.80 | 385 | 2.80 | 1,360 | 3.80 | 2,870 | 5.40 | 6,520 | 8.00 | 14,310 |
| 1.90 | 460 | 2.90 | 1,485 | | | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is well defined below gage height 6.0 feet.

*Monthly discharge of John Day River at McDonald, Oreg., for 1906.*

[Drainage area, 7,800 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 1,550 | 372 | 672 | 41,300 | 0.086 | 0.10 |
| February | 3,010 | 643 | 1,280 | 71,100 | .164 | .17 |
| March | 9,730 | 1,480 | 3,820 | 235,000 | .490 | .56 |
| April | 12,700 | 4,830 | 6,860 | 408,000 | .879 | .98 |
| May | 13,800 | 1,960 | 3,390 | 208,000 | .435 | .50 |
| June | 11,000 | 2,040 | 5,560 | 331,000 | .713 | .80 |
| July | 1,920 | 265 | 760 | 46,700 | .097 | .11 |
| August | 445 | 180 | 236 | 14,500 | .030 | .03 |
| September | 352 | 162 | 234 | 13,900 | .030 | .03 |
| October | 352 | 242 | 288 | 17,700 | .037 | .04 |
| November | 910 | 352 | 506 | 30,100 | .065 | .07 |
| December | 3,440 | 320 | 969 | 59,600 | .124 | .14 |
| The year | 13,800 | 162 | 2,050 | 1,480,000 | .262 | 3.53 |

NOTE.—Values are rated as excellent.

## MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in John Day River drainage basin in 1906:

*Canyon Creek at Canyon City, Oreg.*—The reference point is a cross cut in the top of a cap of a bent on the right bank downstream side of the highway bridge.

July 2, width, 27 feet; area, 22 square feet; gage height, −8.00 feet; discharge, 50 second-feet.

*Rock Creek at Rockcreek, Oreg.*—Rockcreek is a station on the Oregon Railroad and Navigation Company's Condon branch, 6 miles above the mouth of the creek. Measurements are made at a highway bridge near the railway station. The reference point is on top of the first projecting beam from the left bank on upstream side of the bridge; elevation, 15 feet above the datum of the assumed gage.

February 6, width, 24 feet; area, 33 square feet; gage height, 5.67 feet; discharge, 35 second-feet.

February 23, width, 40 feet; area, 62 square feet; gage height, 6.48 feet; discharge, 122 second-feet.

March 16, width, 30 feet; area, 53 square feet; gage height, 6.07 feet; discharge, 87 second-feet.

## DESCHUTES RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Deschutes River and its tributaries drain the eastern slope of the Cascade Mountains in Oregon. The main stream flows northward parallel to this range and empties into Columbia River 15 miles above The Dalles. Its drainage area may be divided into two parts: The tributaries from the west drain the timbered slopes of the Cascade Range; those from the east drain the timberless areas of high table-lands which are devoted largely to the production of wheat and to ranges for sheep and cattle. The soil throughout is composed of disintegrated lava rock, interlaid with porous lava and basalt, a fact which no doubt accounts for the remarkable constancy in the flow of this river and its tributaries from the west. The maximum discharge is only about four times the minimum. The stream is therefore the most valuable in the State. Its power possibilities are phenomenal, and its upper portions furnish an abundance of water for the irrigation of the fertile table-lands. Its principal tributaries are West Fork, Tumalo Creek, Squaw Creek, Crooked River, Metolius River, Warm Springs, and White River, all of which are used for irrigation, power, and logging purposes.

### DESCHUTES RIVER NEAR LAVA, OREG.

This station was established February 17, 1905, about 1 mile north of Lava, Oreg. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 212.

*Discharge measurements of Deschutes River near Lava, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 14 | I. Landes | 56.5 | 181 | 6.21 | 317 |
| May 1 | do | 66.5 | 231 | 6.96 | 422 |
| May 12 | do | 67.0 | 248 | 7.15 | 485 |
| June 12 | do | 56.0 | 215 | 6.94 | 413 |
| June 21 | J. C. Stevens | 61.0 | 210 | 6.67 | 368 |

*Daily gage height, in feet, of Deschutes River near Lava, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.4 | 5.7 | 5.3 | 5.6 | 7.0 | 6.65 | 6.45 | 5.5 | 5.2 | 5.15 | 5.1 | 5.45 |
| 2 | 5.35 | 5.7 | 5.2 | 5.6 | 6.9 | 6.6 | 6.4 | 5.5 | 5.15 | 5.15 | 5.1 | 5.35 |
| 3 | 5.35 | 5.7 | 5.25 | 5.65 | 6.9 | 6.7 | 6.3 | 5.5 | 5.15 | 5.15 | 5.1 | 5.4 |
| 4 | 5.35 | 5.5 | 5.2 | 5.6 | 6.9 | 6.65 | 6.3 | 5.5 | 5.15 | 5.15 | 5.1 | 5.45 |
| 5 | 5.45 | 5.45 | 5.25 | 5.7 | 6.95 | 6.6 | 6.35 | 5.5 | 5.15 | 5.15 | 5.2 | 5.45 |
| 6 | 5.5 | 5.4 | 5.2 | 5.85 | 7.0 | 6.85 | 6.35 | 5.45 | 5.15 | 5.15 | 5.3 | 5.4 |
| 7 | 5.5 | 5.4 | 5.2 | 6.0 | 7.05 | 7.0 | 6.35 | 5.45 | 5.15 | 5.15 | 5.3 | 5.4 |
| 8 | 5.5 | 5.45 | 5.3 | 6.1 | 7.1 | 7.0 | 6.35 | 5.45 | 5.15 | 5.15 | 5.35 | 5.45 |
| 9 | 5.5 | 5.4 | 5.25 | 6.15 | 7.15 | 7.05 | 6.35 | 5.4 | 5.2 | 5.1 | 5.55 | 5.45 |
| 10 | 5.5 | 5.35 | 5.2 | 6.2 | 7.15 | 7.1 | 6.3 | 5.4 | 5.2 | 5.1 | 5.65 | 5.4 |

*Daily gage height, in feet, of Deschutes River near Lava, Oreg., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 5.6 | 5.3 | 5.35 | 6.25 | 7.15 | 7.15 | 6.2 | 5.4 | 5.25 | 5.1 | 5.6 | 5.4 |
| 12 | 5.6 | 5.25 | 5.65 | 6.25 | 7.15 | 7.0 | 6.2 | 5.5 | 5.25 | 5.15 | 5.55 | 5.7 |
| 13 | 5.6 | 5.15 | 5.75 | 6.2 | 7.2 | 6.95 | 6.2 | 5.45 | 5.3 | 5.15 | 5.0 | 5.4 |
| 14 | 5.6 | 5.1 | 5.5 | 6.25 | 7.25 | 6.85 | 6.2 | 5.4 | 5.3 | 5.2 | 5.55 | 5.3 |
| 15 | 5.6 | 5.15 | 5.5 | 6.35 | 7.35 | 6.85 | 6.15 | 5.4 | 5.35 | 5.2 | 5.55 | 5.45 |
| 16 | 5.75 | 5.15 | 5.5 | 6.5 | 7.35 | 6.85 | 6.15 | 5.4 | 5.3 | 5.2 | 5.65 | 5.4 |
| 17 | 5.75 | 5.1 | 5.55 | 6.65 | 7.35 | 6.85 | 6.1 | 5.35 | 5.3 | 5.3 | 5.9 | 5.35 |
| 18 | 5.8 | 5.15 | 5.5 | 6.82 | 7.4 | 6.85 | 6.1 | 5.3 | 5.3 | 5.3 | 5.9 | 5.4 |
| 19 | 5.7 | 5.65 | 5.5 | 6.9 | 7.35 | 6.8 | 6.1 | 5.3 | 5.3 | 5.3 | 5.9 | 5.45 |
| 20 | 5.85 | 5.4 | 5.5 | 6.9 | 7.1 | 6.75 | 5.95 | 5.3 | 5.25 | 5.25 | 5.85 | 5.5 |
| 21 | 5.9 | 5.3 | 5.5 | 6.95 | 6.95 | 6.7 | 5.95 | 5.3 | 5.2 | 5.2 | 5.85 | 5.65 |
| 22 | 5.95 | 5.35 | 5.55 | 7.05 | 6.8 | 6.6 | 5.85 | 5.3 | 5.2 | 5.2 | 5.8 | 5.7 |
| 23 | 5.95 | 5.4 | 5.7 | 7.18 | 6.75 | 6.55 | 5.8 | 5.35 | 5.2 | 5.15 | 5.7 | 5.65 |
| 24 | 5.95 | 5.45 | 5.6 | 7.28 | 6.65 | 6.5 | 5.75 | 5.3 | 5.2 | 5.15 | 5.45 | 5.75 |
| 25 | 6.1 | 5.4 | 5.75 | 7.35 | 6.65 | 6.45 | 5.75 | 5.3 | 5.2 | 5.15 | 5.45 | 5.85 |
| 26 | 6.1 | 5.3 | 5.7 | 7.35 | 6.6 | 6.5 | 5.7 | 5.3 | 5.2 | 5.1 | 5.45 | 5.85 |
| 27 | 6.1 | 5.3 | 5.6 | 7.35 | 6.6 | 6.5 | 5.65 | 5.25 | 5.2 | 5.1 | 5.45 | 5.9 |
| 28 | 6.1 | 5.4 | 5.7 | 7.25 | 6.8 | 6.45 | 5.65 | 5.25 | 5.2 | 5.1 | 5.45 | 6.0 |
| 29 | 6.1 | ..... | 5.7 | 7.2 | 6.85 | 6.45 | 5.65 | 5.2 | 5.2 | 5.1 | 5.45 | 5.9 |
| 30 | 5.9 | ..... | 5.8 | 7.1 | 7.0 | 6.45 | 5.6 | 5.2 | 5.2 | 5.1 | 5.45 | 5.8 |
| 31 | 5.9 | ..... | 5.85 | ..... | 7.05 | ..... | 5.55 | 5.2 | ..... | 5.1 | ..... | 5.8 |

NOTE.—From January 1 to March 22 there was some obstruction from ice, which formed and then went out again, sometimes reaching a thickness of 0.6 foot. There was also some ice November 23 to December 8. Discharges have been applied as for open channel.

*Rating table for Deschutes River near Lava, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| Feet. | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 4.80 | 76 | 5.40 | 125 | 6.00 | 205 | 6.60 | 329 | 7.20 | 498 |
| 4.90 | 82 | 5.50 | 135 | 6.10 | 223 | 6.70 | 355 | 7.30 | 528 |
| 5.00 | 89 | 5.60 | 147 | 6.20 | 242 | 6.80 | 382 | 7.40 | 559 |
| 5.10 | 97 | 5.70 | 160 | 6.30 | 262 | 6.90 | 410 | | |
| 5.20 | 106 | 5.80 | 173 | 6.40 | 283 | 7.00 | 439 | | |
| 5.30 | 115 | 5.90 | 188 | 6.50 | 305 | 7.10 | 468 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 11 discharge measurements made during 1905–6 and is well defined between gage heights 6.0 feet and 7.5 feet. Below gage height 6 feet the measurements are inconsistent.

*Monthly discharge of Deschutes River near Lava, Oreg., for 1906.*

[Drainage area, 880 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 223 | 120 | 166 | 10,200 | 0.189 | 0.22 |
| February | 160 | 97 | 123 | 6,830 | .140 | .15 |
| March | 180 | 106 | 136 | 8,360 | .155 | .18 |
| April | 544 | 147 | 332 | 19,800 | .377 | .42 |
| May | 559 | 329 | 445 | 27,400 | .506 | .58 |
| June | 483 | 294 | 369 | 22,000 | .419 | .47 |
| July | 294 | 141 | 220 | 13,500 | .250 | .29 |
| August | 135 | 106 | 122 | 7,500 | .139 | .16 |
| September | 120 | 102 | 108 | 6,430 | .123 | .14 |
| October | 115 | 97 | 103 | 6,330 | .117 | .13 |
| November | 188 | 89 | 137 | 8,150 | .156 | .17 |
| December | 205 | 115 | 144 | 8,850 | .164 | .19 |
| The year | 559 | 89 | 200 | 145,000 | .228 | 3.10 |

NOTE.—Values are rated as fair.

### DESCHUTES RIVER AT WEST'S RANCH, NEAR LAVA, OREG.

This station was established June 20, 1906. It is located at a private bridge on B. F. West's ranch, 16 miles above Bend. It is below the mouth of West Fork and of Spring River and above all important diversions.

The channel is straight for 200 feet above and 100 feet below the station. The right bank is low, sparsely wooded, and liable to overflow at rare intervals; the left is high and rocky and will not overflow. The bed of the stream is partly of rock and partly of gravel, and will change only during floods.

Measurements are made from a private highway bridge constructed of logs. The initial point is a mark on the guardlog of the bridge, nearly over the gage.

The gage, which is read by B. F. West, is a 2 by 4 inch timber spiked to the approach on the right bank. The bench mark is a spike in the north side of the base of a lone yellow pine, 75 feet upstream from the bridge on the left bank; elevation, 17.44 feet above the datum of the gage.

*Discharge measurements of Deschutes River at West's ranch, near Lava, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 13 | I. Landes | 107 | 588 | 9.08 | 1,590 |
| May 20 | do | 110 | 652 | 9.42 | 1,920 |
| June 12 | do | 110 | 649 | 9.39 | 1,910 |
| June 20 | Stevens and Landes | 110 | 626 | 9.30 | 1,780 |
| August 23 | C. W. Allen | 105 | 576 | 8.85 | 1,400 |

*Daily gage height, in feet, of Deschutes River at West's ranch, near Lava, Oreg., for 1906.*

| Day. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Day. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 8.9 | 8.8 | 8.8 | 8.7 | 8.75 | 17 | ..... | 8.85 | 8.85 | 8.75 | 8.95 | 8.8 |
| 2 | ..... | 8.9 | 8.8 | 8.8 | 8.7 | 8.75 | 18 | ..... | 8.85 | 8.85 | 8.75 | 9.0 | 8.8 |
| 3 | ..... | 8.9 | 8.8 | 8.8 | 8.7 | 8.75 | 19 | ..... | 8.85 | 8.85 | 8.75 | 8.95 | 8.85 |
| 4 | ..... | 8.9 | 8.8 | 8.8 | 8.7 | 8.75 | 20 | ..... | 8.85 | 8.8 | 8.75 | 8.9 | 8.85 |
| 5 | ..... | 8.9 | 8.8 | 8.75 | 8.75 | 8.75 | 21 | 9.0 | 8.85 | 8.8 | 8.75 | 8.9 | 8.85 |
| 6 | ..... | 8.9 | 8.8 | 8.75 | 8.75 | 8.75 | 22 | 9.0 | 8.85 | 8.8 | 8.75 | 8.9 | 8.9 |
| 7 | ..... | 8.9 | 8.8 | 8.75 | 8.8 | 8.8 | 23 | 8.98 | 8.85 | 8.8 | 8.7 | 8.8 | 8.9 |
| 8 | ..... | 8.9 | 8.8 | 8.75 | 8.8 | 8.8 | 24 | 8.95 | 8.85 | 8.8 | 8.7 | 8.8 | 8.9 |
| 9 | ..... | 8.9 | 8.8 | 8.75 | 8.8 | 8.8 | 25 | 8.95 | 8.85 | 8.8 | 8.7 | 8.82 | 8.9 |
| 10 | ..... | 8.9 | 8.8 | 8.75 | 8.88 | 8.8 | 26 | 8.95 | 8.85 | 8.8 | 8.7 | 8.75 | 8.98 |
| 11 | ..... | 8.9 | 8.8 | 8.75 | 8.85 | 8.8 | 27 | 8.95 | 8.85 | 8.8 | 8.7 | 8.7 | 9.0 |
| 12 | ..... | 8.9 | 8.8 | 8.78 | 8.85 | 8.75 | 28 | 8.95 | 8.85 | 8.8 | 8.7 | 8.72 | 9.0 |
| 13 | ..... | 8.9 | 8.82 | 8.75 | 8.8 | 8.75 | 29 | 8.95 | 8.8 | 8.8 | 8.7 | 8.72 | 8.95 |
| 14 | ..... | 8.9 | 8.85 | 8.75 | 8.8 | 8.8 | 30 | 8.92 | 8.8 | 8.8 | 8.7 | 8.75 | 8.95 |
| 15 | ..... | 8.85 | 8.85 | 8.75 | 8.85 | 8.8 | 31 | 8.90 | 8.8 | ..... | 8.7 | ..... | 8.9 |
| 16 | ..... | 8.85 | 8.85 | 8.75 | 8.9 | 8.78 | | | | | | | |

*Rating table for Deschutes River at West's ranch, near Lava, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 8.70 | 1,290 | 8.90 | 1,430 | 9.10 | 1,590 | 9.30 | 1,780 | 9.40 | 1,900 |
| 8.80 | 1,360 | 9.00 | 1,510 | 9.20 | 1,680 | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 5 discharge measurements made during 1906 and is well defined.

*Monthly discharge of Deschutes River at West's ranch, near Lava, Oreg., for 1906.*

[Drainage area, 1,240 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| July 21–31 | 1,510 | 1,430 | 1,470 | 32,100 | 1.19 | 0.49 |
| August | 1,430 | 1,360 | 1,410 | 86,700 | 1.14 | 1.31 |
| September | 1,400 | 1,360 | 1,370 | 81,500 | 1.10 | 1.23 |
| October | 1,360 | 1,290 | 1,320 | 81,200 | 1.06 | 1.22 |
| November | 1,510 | 1,290 | 1,370 | 81,500 | 1.10 | 1.23 |
| December | 1,510 | 1,320 | 1,390 | 85,500 | 1.12 | 1.29 |
| The period | | | | 448,000 | | |

NOTE.—Values are rated as excellent.

## DESCHUTES RIVER AT BEND, OREG.

This station was established December 22, 1904. It is located at the wagon bridge known as Sizemore's bridge, 1½ miles south of Bend, Oreg.

On account of backwater from logs and other disturbing influences the gage heights at this station are no index of the discharge, which is practically the same as at West's ranch. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 208, where are given also references to publications that contain data for previous years.

*Discharge measurements of Deschutes River at Bend, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 19 | I. Landes | 370.5 | 747 | 1.78 | 1,680 |
| June 19 | J. C. Stevens | 376 | 883 | 2.11 | 1,880 |

## DESCHUTES RIVER NEAR BIGGS, OREG.

This station was established July 7, 1906. It is located at Taylor's ranch, 1½ miles above the junction of the river with the Columbia, about the same distance above the Oregon Railroad and Navigation Company's bridge, and 1 mile above Moody's toll bridge.

The channel is straight; the banks are overgrown with alder and not liable to overflow. The bed of the stream is of rock and gravel, free from vegetation, and liable to shift slightly. There is but one channel at all stages. There is a good even current at the gaging section; a little lower down it is considerably broken by falls and riffles.

Measurements are made from a car and cable of 490 feet span. The initial point for soundings is 8 feet from the inside of the shear leg on the left bank. There is a tagged wire overhead and a stay-line 100 feet upstream.

The gage, which is read by Wilbur Taylor, is 150 yards below the point of measurement, on the right bank. It is in two sections and

is bolted to alder trees. The bench mark is the top of three 20-penny nails driven into the trunk of the alder tree to which the lower part of the gage is anchored; elevation, 5.46 feet above the datum of the gage.

*Discharge measurements of Deschutes River near Biggs, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| July 7 | L. R. Allen | 452 | 1,610 | 2.63 | 6,010 |
| August 30 | do | 449 | 1,550 | 2.34 | 5,140 |
| September 29 | I. E. Oakes | 435 | 1,530 | 2.30 | 5,000 |
| October 18 | Stevens and Oakes | 450 | 1,530 | 2.35 | 5,320 |
| December 17 | H. D. McGlashan | 449 | 1,650 | 2.64 | 5,710 |

*Daily gage height, in feet, of Deschutes River near Biggs, Oreg., for 1906.*

| Day. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Day. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 2.4 | 2.3 | 2.3 | 2.35 | 2.56 | 17 | ..... | 2.4 | 2.3 | 2.3 | 3.6 | 2.63 |
| 2 | ..... | 2.4 | 2.3 | 2.3 | 2.35 | ..... | 18 | ..... | 2.4 | 2.3 | 2.35 | 3.46 | ..... |
| 3 | ..... | 2.4 | 2.3 | 2.3 | 2.35 | 2.55 | 19 | ..... | 2.4 | 2.3 | 2.35 | ..... | 2.65 |
| 4 | ..... | 2.4 | 2.3 | 2.3 | 2.35 | ..... | 20 | ..... | 2.4 | 2.3 | 2.35 | 3.1 | ..... |
| 5 | ..... | 2.4 | 2.3 | 2.3 | 2.35 | 2.55 | 21 | ..... | 2.4 | 2.3 | 2.35 | 2.85 | 3.5 |
| 6 | ..... | 2.4 | 2.3 | 2.3 | 2.35 | 2.55 | 22 | 2.4 | 2.4 | 2.3 | 2.35 | 2.75 | 3.25 |
| 7 | ..... | 2.4 | 2.3 | 2.3 | 2.45 | ..... | 23 | 2.4 | 2.4 | 2.3 | 2.35 | ..... | ..... |
| 8 | ..... | 2.4 | 2.3 | 2.3 | 3.25 | 2.66 | 24 | 2.4 | 2.4 | 2.3 | 2.35 | 2.7 | 3.18 |
| 9 | ..... | 2.4 | 2.3 | 2.3 | ..... | ..... | 25 | 2.4 | 2.4 | 2.3 | 2.35 | ..... | 3.1 |
| 10 | ..... | 2.4 | 2.3 | 2.3 | 2.9 | 2.62 | 26 | 2.4 | 2.4 | 2.3 | 2.35 | 2.65 | ..... |
| 11 | ..... | 2.4 | 2.3 | 2.3 | 3.0 | 2.6 | 27 | 2.4 | 2.4 | 2.3 | 2.56 | ..... | 3.08 |
| 12 | ..... | 2.4 | 2.3 | 2.3 | ..... | ..... | 28 | 2.4 | 2.4 | 2.3 | 2.4 | 2.6 | ..... |
| 13 | ..... | 2.4 | 2.3 | 2.3 | 3.8 | 2.58 | 29 | 2.4 | 2.4 | 2.3 | 2.39 | ..... | 3.03 |
| 14 | ..... | 2.4 | 2.3 | 2.3 | 3.65 | ..... | 30 | 2.4 | 2.4 | 2.3 | 2.36 | 2.58 | 3.0 |
| 15 | ..... | 2.4 | 2.3 | 2.3 | 4.1 | 2.55 | 31 | 2.4 | 2.4 | ..... | 2.35 | ..... | 2.98 |
| 16 | ..... | 2.4 | 2.3 | 2.3 | 3.9 | ..... | | | | | | | |

*Rating table for Deschutes River near Biggs, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.30 | 5,140 | 2.70 | 6,060 | 3.10 | 7,020 | 3.50 | 8,000 | 3.90 | 9,000 |
| 2.40 | 5,370 | 2.80 | 6,300 | 3.20 | 7,260 | 3.60 | 8,250 | 4.00 | 9,250 |
| 2.50 | 5,600 | 2.90 | 6,540 | 3.30 | 7,500 | 3.70 | 8,500 | 4.10 | 9,500 |
| 2.60 | 5,830 | 3.00 | 6,780 | 3.40 | 7,750 | 3.80 | 8,750 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 5 discharge measurements made during 1906 and is fairly well defined below gage height 2.7 feet.

*Monthly discharge of Deschutes River near Biggs, Oreg., for 1906.*

[Drainage area, 9,180 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| July 22-31 | 5,370 | 5,370 | 5,370 | 106,000 | 0.585 | 0.22 |
| August | 5,370 | 5,370 | 5,370 | 330,000 | .585 | .67 |
| September | 5,140 | 5,140 | 5,140 | 306,000 | .560 | .62 |
| October | 5,740 | 5,140 | 5,220 | 321,000 | .569 | .66 |
| November | 9,500 | 5,260 | 6,640 | 395,000 | .723 | .81 |
| December | 8,000 | 5,720 | 6,360 | 391,000 | .693 | .80 |
| The period | ..... | ..... | ..... | 1,850,000 | ..... | ..... |

NOTE.—Values are rated as fair.

## EAST FORK OF DESCHUTES RIVER AT ODELL, OREG.

This station was established December 25, 1904, at Odell post-office. The conditions and the bench marks are described in Water-Supply Paper No. 178, page 210, where are given also references to publications that contain data for previous years.

*Discharge measurements of East Fork of Deschutes River at Odell, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 11 | I. Landes | 24 | 34 | 2.70 | 63 |
| May 21 | do | 25 | 43 | 3.15 | 101 |
| June 14 | do | 25.5 | 47 | [a] 3.40 | 118 |
| June 21 | Stevens and Landes | 25.5 | 44 | 3.15 | 109 |

[a] Gage height uncertain.

*Daily gage height, in feet, of East Fork of Deschutes River at Odell, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.1 | 3.2 | 3.1 | 2.6 | 3.25 | 3.1 | 3.0 | 2.4 | 2.2 | 2.2 | 2.2 | 2.75 |
| 2 | 3.1 | 3.2 | 2.7 | 2.6 | 3.25 | 3.1 | 3.0 | 2.4 | 2.2 | 2.2 | 2.2 | 2.65 |
| 3 | 3.0 | 3.2 | 3.05 | 2.92 | 3.3 | 3.1 | 2.9 | 2.4 | 2.2 | 2.2 | 2.2 | 2.7 |
| 4 | 3.0 | 2.8 | 3.1 | 2.6 | 3.35 | 3.2 | 3.0 | 2.3 | 2.2 | 2.2 | 2.3 | 2.75 |
| 5 | 3.0 | 2.8 | 3.0 | 2.55 | 3.4 | 3.3 | 3.1 | 2.3 | 2.2 | 2.2 | 2.3 | 2.5 |
| 6 | 3.0 | 3.1 | 2.9 | 2.75 | 3.5 | 3.4 | 3.1 | 2.3 | 2.5 | 2.2 | 2.4 | 2.5 |
| 7 | 3.0 | 2.9 | 2.9 | 2.5 | 3.5 | 3.3 | 3.0 | 2.2 | 2.5 | 2.2 | 2.6 | 2.5 |
| 8 | 3.0 | 2.9 | 3.0 | 2.8 | 3.45 | 3.3 | 2.9 | 2.2 | 2.5 | 2.2 | 2.4 | 2.5 |
| 9 | 3.0 | 2.8 | 2.9 | 2.85 | 3.5 | 3.3 | 2.8 | 2.2 | 2.5 | 2.2 | 2.4 | 2.5 |
| 10 | 2.8 | 2.9 | 2.85 | 2.85 | 3.55 | 3.2 | 2.8 | 2.2 | 2.5 | 2.2 | 2.4 | 2.5 |
| 11 | 2.8 | 3.0 | 2.9 | 2.7 | 3.55 | 3.2 | 2.75 | 2.2 | 2.5 | 2.2 | 2.65 | 2.7 |
| 12 | 2.8 | 3.1 | 2.8 | 2.7 | 3.6 | 3.3 | 2.75 | 2.3 | 2.5 | 2.2 | 2.65 | 2.6 |
| 13 | 2.9 | 3.1 | 2.5 | 2.75 | 3.6 | 3.3 | 2.7 | 2.3 | 2.3 | 2.2 | 2.65 | 2.5 |
| 14 | 2.9 | 3.1 | 3.0 | 2.8 | 3.7 | 3.4 | 2.7 | 2.3 | 2.4 | 2.2 | 2.65 | 2.5 |
| 15 | 3.1 | 3.0 | 2.9 | 2.9 | 3.7 | 3.4 | 2.7 | 2.3 | 2.4 | 2.2 | 2.4 | 2.4 |
| 16 | 3.1 | 3.0 | 2.8 | 3.0 | 3.6 | 3.5 | 2.7 | 2.3 | 2.3 | 2.2 | 2.7 | 2.5 |
| 17 | 2.4 | 3.1 | 2.7 | 3.0 | 3.4 | 3.5 | 2.7 | 2.3 | 2.3 | 2.65 | 2.6 | 2.5 |
| 18 | 2.2 | 3.2 | 2.7 | 3.0 | 3.3 | 3.4 | 2.7 | 2.3 | 2.3 | 2.3 | 2.65 | 2.5 |
| 19 | 2.2 | 3.2 | 2.8 | 3.0 | 3.1 | 3.2 | 2.6 | 2.3 | 2.3 | 2.3 | 2.4 | 2.6 |
| 20 | 2.18 | 3.35 | 2.8 | 3.0 | 3.0 | 3.1 | 2.6 | 2.3 | 2.2 | 2.3 | 2.6 | 2.5 |
| 21 | 3.5 | 3.5 | 2.8 | 3.3 | 3.1 | 3.1 | 2.65 | 2.3 | 2.2 | 2.65 | 2.6 | 2.5 |
| 22 | 3.0 | 3.3 | 2.85 | 3.4 | 3.1 | 3.1 | 2.5 | 2.3 | 2.2 | 2.65 | 2.55 | 2.45 |
| 23 | 3.4 | 3.3 | 3.2 | 3.4 | 2.9 | 3.1 | 2.5 | 2.3 | 2.2 | 2.65 | 2.5 | 2.4 |
| 24 | 3.4 | 3.0 | 3.1 | 3.4 | 2.9 | 3.0 | 2.5 | 2.5 | 2.2 | 2.65 | 2.68 | 2.45 |
| 25 | 3.4 | 2.85 | 3.1 | 3.45 | 2.9 | 3.0 | 2.5 | 2.5 | 2.2 | 2.2 | 2.65 | 2.5 |
| 26 | 3.4 | 2.85 | 3.0 | 3.3 | 3.0 | 3.0 | 2.45 | 2.5 | 2.2 | 2.2 | 2.85 | 2.7 |
| 27 | 2.9 | 2.8 | 3.0 | 3.25 | 3.0 | 3.0 | 2.45 | 2.5 | 2.2 | 2.2 | 2.85 | 2.6 |
| 28 | 3.2 | 3.25 | 2.75 | 3.25 | 3.3 | 3.0 | 2.45 | 2.5 | 2.2 | 2.2 | 2.65 | 2.5 |
| 29 | 3.2 | ..... | 2.65 | 3.2 | 3.2 | 3.0 | 2.45 | 2.2 | 2.2 | 2.2 | 2.7 | 2.5 |
| 30 | 3.2 | ..... | 2.7 | 3.25 | 3.2 | 3.0 | 2.4 | 2.2 | 2.2 | 2.2 | 2.65 | 2.5 |
| 31 | 3.2 | ..... | 3.1 | ..... | 3.1 | ..... | 2.4 | 2.2 | ..... | 2.2 | ..... | 2.4 |

*Rating table for East Fork of Deschutes River at Odell, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.10 | 24 | 2.50 | 49 | 2.90 | 81 | 3.30 | 121 | 3.70 | 174 |
| 2.20 | 30 | 2.60 | 56 | 3.00 | 90 | 3.40 | 133 | | |
| 2.30 | 36 | 2.70 | 64 | 3.10 | 100 | 3.50 | 146 | | |
| 2.40 | 42 | 2.80 | 72 | 3.20 | 110 | 3.60 | 160 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 3 discharge measurements made during 1906 and the form of previous curves and is fairly well defined.

*Monthly discharge of East Fork of Deschutes River at Odell, Oreg., for 1906.*

[Drainage area, 196 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 146 | 29 | 88.8 | 5,460 | 0.454 | 0.52 |
| February | 146 | 72 | 97.6 | 5,420 | .498 | .52 |
| March | 110 | 60 | 80.8 | 4,970 | .413 | .48 |
| April | 140 | 49 | 89.7 | 5,340 | .458 | .51 |
| May | 174 | 81 | 124 | 7,620 | .633 | .73 |
| June | 146 | 90 | 110 | 6,540 | .562 | .63 |
| July | 100 | 42 | 65.2 | 4,010 | .333 | .38 |
| August | 49 | 30 | 37.8 | 2,320 | .196 | .23 |
| September | 49 | 30 | 36.2 | 2,150 | .185 | .21 |
| October | 60 | 30 | 35.4 | 2,180 | .182 | .21 |
| November | 77 | 30 | 52.0 | 3,090 | .265 | .30 |
| December | 68 | 42 | 52.0 | 3,200 | .265 | .31 |
| The year | 174 | 29 | 73.0 | 52,300 | .522 | 5.03 |

NOTE.—Values are rated as fair.

## WEST FORK OF DESCHUTES RIVER NEAR LAVA, OREG.

This station was established February 20, 1905, about 1½ miles west of Lava, Oreg. The conditions and the bench marks are described in Water-Supply Paper No. 178, page 214, where are given also references to publications that contain data for previous years.

*Discharge measurements of West Fork of Deschutes River near Lava, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 13 | I. Landes | 99 | 453 | 7.91 | 910 |
| May 2 | do | 100 | 468 | 8.10 | 880 |
| May 13 | do | 100 | 485 | 8.30 | 942 |
| June 11 | do | 101 | 485 | 8.39 | 955 |
| June 21 | Stevens and Landes | 101 | 484 | 8.26 | 914 |

*Daily gage height, in feet, of West Fork of Deschutes River near Lava, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 7.52 | | | | | | 8.05 | | | | |
| 2 | 8.01 | 7.50 | | | | | | | | 8.10 | 7.90 | |
| 3 | | 7.50 | 7.50 | | | | | | | | | |
| 4 | 7.70 | 7.50 | | | | | 8.15 | | | | | |
| 5 | 7.62 | 7.50 | | | 8.50 | 8.35 | | 8.10 | | 8.00 | | |
| 6 | 7.62 | 7.50 | | | | | | | | | | |
| 7 | 7.65 | 7.50 | | 7.80 | | | | | 8.01 | | | |
| 8 | 7.60 | 7.50 | | | 8.15 | | | | | | | 8.10 |
| 9 | 7.60 | 7.50 | | | | | | | | 8.00 | 8.00 | |
| 10 | 7.60 | 7.50 | 7.60 | | | | | | | | | |
| 11 | 7.60 | 7.50 | | | | | 8.15 | | | | 8.00 | |
| 12 | 7.60 | 7.50 | | | | 8.40 | | 8.15 | | 8.10 | 7.90 | |
| 13 | 7.70 | 7.50 | | | 8.30 | | | | | | | |
| 14 | 7.65 | 7.50 | | 8.00 | | | | | 8.20 | | | |
| 15 | 7.65 | 7.50 | | | | | | | | | | 7.90 |
| 16 | 7.85 | 7.50 | | | | | | | | 8.10 | 8.10 | |
| 17 | 7.62 | 7.55 | 7.40 | | 8.40 | | | | | | | |
| 18 | 7.70 | 7.62 | | | | | 8.15 | | | | | |
| 19 | 7.66 | 7.70 | | | | | | 8.10 | | 8.00 | | |
| 20 | 7.60 | 7.65 | | | 8.30 | | | | | | | |

*Daily gage height, in feet, of West Fork of Deschutes River near Lava, Oreg., in 1906—* Continued.

| Day. | Jan. | Feb. | Mar. | Apr | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 7.55 | 7.60 | ..... | ..... | ..... | 8.26 | ..... | ..... | 8.01 | ..... | ..... | ..... |
| 22 | 7.60 | 7.60 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 7.70 |
| 23 | 7.65 | 7.60 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 24 | 7.66 | 7.60 | 7.50 | ..... | ..... | 8.20 | 8.10 | ..... | ..... | ..... | 7.95 | ..... |
| 25 | 7.60 | 7.60 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 26 | 7.60 | ..... | ..... | ..... | ..... | 8.25 | ..... | 8.15 | ..... | 7.95 | ..... | ..... |
| 27 | 7.58 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 28 | 7.55 | 7.50 | ..... | 8.20 | ..... | ..... | ..... | ..... | 8.01 | ..... | ..... | ..... |
| 29 | 7.55 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 8.00 |
| 30 | 7.55 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 7.90 | ..... |
| 31 | 7.55 | ..... | 7.75 | ..... | ..... | ..... | ..... | 8.15 | ..... | ..... | ..... | ..... |

NOTE.—There was some floating ice during January.

*Rating tables for West Fork of Deschutes River near Lava, Oreg.*

JANUARY 1, 1905, TO APRIL 30, 1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 7.40 | 837 | 7.60 | 867 | 7.80 | 902 | 8.00 | 942 | 8.20 | 984 |
| 7.50 | 852 | 7.70 | 883 | 7.90 | 922 | 8.10 | 963 | | |

MAY 1 TO DECEMBER 31, 1906.[b]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 7.50 | 727 | 7.80 | 802 | 8.10 | 879 | 8.40 | 958 | 8.50 | 985 |
| 7.60 | 752 | 7.90 | 827 | 8.20 | 905 | | | | |
| 7.70 | 777 | 8.00 | 853 | 8.30 | 931 | | | | |

[a] This table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is well defined above gage height, 7.7 feet.

[b] This table is applicable only for open-channel conditions. It is based on 4 discharges measurements made during 1906 and is well defined above gage height 8.1 feet. The table has been extended beyond these limits.

*Monthly discharge of West Fork of Deschutes River near Lava, Oreg., for 1906.*

[Drainage area, 360 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| January | 944 | 860 | 874 | 53,700 | 2.43 | 2.80 |
| February | 883 | 852 | 858 | 47,700 | 2.38 | 2.48 |
| March | 892 | 837 | 860 | 52,900 | 2.39 | 2.76 |
| April | 984 | 902 | 943 | 56,100 | 2.62 | 2.92 |
| May | 985 | 892 | 939 | 57,700 | 2.61 | 3.01 |
| June | 958 | 905 | 929 | 55,300 | 2.58 | 2.88 |
| July | 892 | 879 | 889 | 54,700 | 2.47 | 2.85 |
| August | 892 | 866 | 883 | 54,300 | 2.45 | 2.82 |
| September | 905 | 856 | 868 | 51,600 | 2.41 | 2.69 |
| October | 879 | 840 | 862 | 53,000 | 2.39 | 2.76 |
| November | 879 | 827 | 844 | 50,200 | 2.34 | 2.61 |
| December | 879 | 777 | 834 | 51,300 | 2.32 | 2.68 |
| The year | 985 | 777 | 882 | 638,000 | 2.45 | 33.26 |

NOTE.—Owing to the steady flow of the river the mean discharge for the days of each month when the gage was read has been taken as the mean for the month. Values are good.

## CENTRAL OREGON AND PILOT BUTTE CANALS, NEAR BEND, OREG.

These canals have a common head-gate and are operated by the Deschutes Irrigation and Power Company, under the provisions of the Carey Act. They divert water from Deschutes River about 3 miles above Bend. Measurements are made 2,000 feet below dividing point. The conditions at these stations are described in Water-Supply Paper No. 178, pages 216–217.

*Discharge measurements of Central Oregon canal near Bend, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 18 | I. Landes | 13.3 | 11 | 0.80 | 35 |
| May 18 | do | 13.3 | 17 | 1.25 | 66 |
| June 10 | do | 13.3 | 19 | 1.45 | 86 |
| June 19 | J. C. Stevens | 13.4 | 19 | 1.44 | 92 |
| June 19 | I. Landes | 13.4 | 19 | 1.44 | 90 |
| June 19 | L. R. Allen | 13.4 | 19 | 1.44 | 87 |
| August 22 | C. W. Allen | 13.3 | 25 | 1.87 | 134 |

*Daily gage height, in feet, of Central Oregon canal near Bend, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1.35 | 1.25 | 1.25 | .80 | 1.25 | 1.58 | 1.80 | 1.87 | 1.84 | 1.68 | 1.09 |
| 2 | | 1.25 | .90 | 1.25 | | 1.25 | 1.58 | 1.80 | 1.88 | 1.84 | 1.65 | .98 |
| 3 | .38 | 1.60 | 1.15 | 1.25 | 1.12 | 1.25 | 1.58 | 1.80 | 1.87 | 1.82 | 1.59 | .98 |
| 4 | .90 | 1.60 | 1.30 | 1.25 | 1.30 | 1.25 | 1.58 | 1.80 | 1.87 | 1.84 | 1.08 | .98 |
| 5 | .90 | 1.20 | 1.20 | 1.25 | 1.20 | 1.25 | 1.61 | 1.80 | 1.87 | 1.84 | 1.09 | 1.09 |
| 6 | .90 | .95 | .60 | 1.25 | 1.20 | 1.25 | 1.64 | 1.80 | 1.87 | 1.84 | 1.6 | 1.19 |
| 7 | 1.00 | .65 | .60 | 1.25 | .60 | 1.25 | 1.64 | 1.80 | 1.87 | 1.84 | 1.48 | 1.20 |
| 8 | .55 | .65 | .60 | 1.12 | .60 | 1.35 | 1.65 | 1.80 | 1.86 | 1.84 | 1.10 | 1.20 |
| 9 | | .65 | .90 | .90 | 1.20 | 1.45 | 1.65 | 1.80 | 1.87 | 1.84 | 1.02 | 1.20 |
| 10 | | .65 | .90 | .82 | 1.22 | 1.45 | 1.67 | 1.80 | 1.87 | 1.84 | 0.51 | 1.20 |
| 11 | | .32 | | .85 | 1.20 | 1.45 | 1.69 | 1.80 | 1.87 | 1.83 | | 1.20 |
| 12 | .62 | .33 | .35 | 1.20 | 1.20 | 1.45 | 1.85 | 1.80 | 1.87 | 1.83 | | 1.20 |
| 13 | .43 | .32 | .45 | 1.25 | 1.20 | 1.45 | 1.84 | 1.80 | 1.85 | 1.84 | | 1.20 |
| 14 | 1.42 | .65 | | 1.25 | 1.20 | 1.45 | 1.85 | 1.80 | 1.84 | 1.84 | 1.00 | 1.38 |
| 15 | 1.50 | 1.10 | | 1.25 | 1.20 | 1.45 | 1.85 | 1.80 | 1.84 | 1.84 | 1.40 | 1.54 |
| 16 | 1.20 | .65 | | .62 | 1.20 | 1.45 | 1.77 | 1.87 | 1.84 | 1.82 | 1.60 | 1.55 |
| 17 | | | | .40 | 1.20 | 1.45 | 1.70 | 1.87 | 1.84 | 1.80 | 1.58 | 1.55 |
| 18 | | | | .78 | 1.20 | 1.45 | 1.70 | 1.87 | 1.84 | 1.77 | | 1.55 |
| 19 | | | | .90 | 1.20 | 1.45 | 1.70 | 1.87 | 1.84 | 1.77 | .20 | 1.55 |
| 20 | | | | .85 | 1.10 | 1.45 | 1.70 | 1.87 | 1.84 | 1.77 | .62 | 1.55 |
| 21 | | | | .75 | 1.10 | 1.45 | 1.70 | 1.87 | 1.84 | 1.76 | .98 | 1.55 |
| 22 | | | | .75 | 1.10 | 1.48 | 1.70 | 1.87 | 1.84 | 1.77 | .38 | 1.55 |
| 23 | | | | .78 | 1.10 | 1.53 | 1.70 | 1.87 | 1.82 | 1.77 | .40 | 1.55 |
| 24 | | | | .75 | 1.10 | 1.53 | 1.70 | 1.87 | 1.84 | 1.77 | .60 | 1.38 |
| 25 | 1.50 | | .55 | .80 | 1.10 | 1.53 | 1.70 | 1.77 | 1.84 | 1.76 | .77 | 1.20 |
| 26 | 1.40 | | 1.05 | .82 | 1.10 | 1.53 | 1.80 | 1.77 | 1.84 | 1.76 | .90 | 1.20 |
| 27 | 1.25 | .50 | 1.05 | .85 | 1.25 | 1.53 | 1.80 | 1.82 | 1.84 | 1.77 | 1.00 | 1.20 |
| 28 | 1.50 | .50 | 1.12 | .92 | 1.25 | 1.53 | 1.88 | 1.87 | 1.84 | 1.77 | 1.10 | 1.20 |
| 29 | 1.40 | | 1.20 | 1.20 | 1.25 | 1.53 | 1.81 | 1.88 | 1.84 | 1.77 | 1.20 | 1.20 |
| 30 | 1.40 | | 1.25 | 1.20 | 1.25 | 1.53 | 1.80 | 1.87 | 1.82 | 1.77 | 1.20 | 1.20 |
| 31 | 1.52 | | 1.25 | | 1.25 | | 1.79 | 1.87 | | 1.72 | | |

NOTE.—The canal was dry on days when the gage height was not recorded.

*Rating table for Central Oregon canal near Bend, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.00 | 0 | 0.40 | 12 | 0.80 | 34 | 1.20 | 65 | 1.60 | 105 |
| 0.10 | 2 | 0.50 | 17 | 0.90 | 41 | 1.30 | 74 | 1.70 | 116 |
| 0.20 | 5 | 0.60 | 22 | 1.00 | 48 | 1.40 | 84 | 1.80 | 128 |
| 0.30 | 8 | 0.70 | 28 | 1.10 | 56 | 1.50 | 94 | 1.90 | 140 |

NOTE.—The above table is based on 12 discharge measurements made during 1905-6 and is well defined.

*Monthly discharge of Central Oregon canal near Bend, Oreg., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 96 | 0 | 35.2 | 2,160 |
| February | 105 | 0 | 26.2 | 1,460 |
| March | 74 | 0 | 28.0 | 1,720 |
| April | 70 | 12 | 49.6 | 2,950 |
| May | 74 | 0 | 58.0 | 3,570 |
| June | 97 | 70 | 86.5 | 5,150 |
| July | 138 | 103 | 118 | 7,260 |
| August | 138 | 124 | 131 | 8,060 |
| September | 138 | 130 | 134 | 7,970 |
| October | 133 | 118 | 128 | 7,870 |
| November | 114 | 0 | 48.5 | 2,890 |
| December | 100 | 47 | 73.8 | 4,540 |
| The year | 138 | 0 | 76.4 | 55,600 |

NOTE.—Values are rated as good.

*Discharge measurements of Pilot Butte canal near Bend, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 18 | I. Landes | 31.5 | 33 | 1.85 | 37 |
| May 18 | do | 33 | 42 | 2.10 | 62 |
| June 10 | do | 33 | 51 | 2.30 | 95 |
| June 18 | L. R. Allen | 44 | 58 | 2.30 | 99 |
| June 19 | J. C. Stevens | 34 | 52 | 2.30 | 99 |

*Daily gage height, in feet, of Pilot Butte canal near Bend, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 1.95 | ..... | 1.85 | 2.05 | 2.15 | 2.44 | 2.60 | 2.28 | 2.46 | 1.52 | 1.40 |
| 2 | ..... | 1.95 | 1.85 | 1.50 | 2.05 | 2.15 | 2.44 | 2.62 | 2.45 | 2.45 | ..... | 1.36 |
| 3 | .88 | ..... | 1.95 | 1.50 | 2.05 | 2.15 | 2.44 | 2.60 | 2.46 | 2.43 | 1.37 | 1.40 |
| 4 | 1.85 | ..... | 1.90 | 1.62 | 2.10 | 2.10 | 2.44 | 2.60 | 2.46 | 2.44 | 1.34 | 1.59 |
| 5 | .98 | ..... | 1.85 | 1.50 | 2.15 | 2.30 | 2.44 | 2.60 | 2.46 | 2.46 | 1.38 | 1.79 |
| 6 | 1.95 | ..... | 1.85 | 1.50 | 2.15 | 2.30 | 2.44 | 2.60 | 2.46 | 2.46 | 1.38 | 1.60 |
| 7 | 1.95 | ..... | 1.85 | 1.62 | 2.15 | 2.30 | 2.51 | 2.60 | 2.46 | 2.46 | 1.80 | 1.75 |
| 8 | ..... | 1.95 | 1.82 | 1.62 | 2.15 | 2.30 | 2.56 | 2.60 | 2.46 | 2.46 | 2.26 | 1.90 |
| 9 | ..... | 1.95 | 1.73 | 1.84 | 2.15 | 2.30 | 2.60 | 2.60 | 2.46 | 2.46 | ..... | 1.90 |
| 10 | 1.90 | 1.95 | 1.82 | 2.18 | 2.22 | 2.30 | 2.60 | 2.60 | 2.46 | 2.46 | ..... | 1.64 |
| 11 | 1.80 | 1.95 | ..... | 2.30 | 2.35 | 2.30 | 2.60 | 2.60 | 2.46 | 2.45 | 1.10 | 1.40 |
| 12 | .95 | 1.95 | ..... | 2.30 | 2.35 | 2.30 | 2.60 | 2.60 | 2.46 | 2.44 | 1.36 | 1.40 |
| 13 | ..... | 1.85 | ..... | 2.05 | 2.40 | 2.30 | 2.60 | 2.60 | 2.46 | 2.44 | 1.14 | 1.40 |
| 14 | ..... | 1.85 | ..... | 2.05 | 2.40 | 2.30 | 2.60 | 2.60 | 2.46 | 2.46 | 1.06 | 1.39 |
| 15 | ..... | 1.85 | ..... | 2.05 | 2.40 | 2.30 | 2.60 | 2.60 | 2.46 | 2.46 | 1.02 | 1.42 |
| 16 | ..... | 1.85 | ..... | 2.00 | 2.40 | 2.30 | 2.60 | 2.60 | 2.46 | 2.44 | 1.48 | 1.74 |
| 17 | ..... | 1.85 | ..... | 2.45 | 2.40 | 2.30 | 2.60 | 2.60 | 2.46 | 2.46 | 1.38 | 1.90 |
| 18 | ..... | 1.85 | ..... | 2.45 | 2.05 | 2.30 | 2.60 | 2.60 | 2.46 | 2.46 | 1.42 | 1.90 |
| 19 | ..... | 1.85 | ..... | 1.95 | 2.05 | 2.30 | 2.60 | 2.60 | 2.46 | 2.46 | 1.42 | 1.92 |
| 20 | ..... | 1.85 | ..... | 1.95 | 2.05 | 2.30 | 2.59 | 2.59 | 2.46 | 2.46 | 1.51 | 1.92 |
| 21 | ..... | 1.85 | ..... | 1.95 | 2.10 | 2.30 | 2.60 | 2.60 | 2.46 | 2.46 | 1.74 | 1.92 |
| 22 | ..... | 1.85 | ..... | 1.95 | 2.15 | 2.30 | 2.60 | 2.60 | 2.46 | 2.46 | 1.59 | 1.92 |
| 23 | ..... | 1.85 | ..... | 1.78 | 2.15 | 2.30 | 2.59 | 2.60 | 2.43 | 1.73 | 1.64 | 1.92 |
| 24 | ..... | 1.85 | 1.78 | 2.05 | 2.15 | 2.37 | 2.60 | 2.60 | 2.46 | 1.62 | 2.10 | 1.92 |
| 25 | ..... | 1.85 | 1.95 | 2.05 | 2.15 | 2.42 | 2.60 | 2.60 | 2.46 | 2.29 | 2.10 | 1.92 |
| 26 | 1.50 | 1.90 | 1.90 | 2.05 | 2.15 | 2.44 | 2.60 | ..... | 2.46 | 2.30 | 2.10 | 1.92 |
| 27 | 1.75 | .97 | 1.95 | 2.05 | 2.20 | 2.44 | 2.60 | 2.60 | 2.46 | 2.30 | 1.75 | 1.92 |
| 28 | .90 | .98 | ..... | 2.05 | 2.20 | 2.44 | 2.59 | 2.58 | 2.46 | 2.30 | 1.40 | 1.92 |
| 29 | .95 | ..... | .85 | 2.05 | 2.35 | 2.44 | 2.60 | ..... | 2.46 | 2.30 | 1.38 | 1.92 |
| 30 | 1.80 | ..... | ..... | 2.05 | 2.40 | 2.44 | 2.58 | 2.18 | 2.44 | 2.30 | 1.40 | 1.92 |
| 31 | 1.70 | ..... | ..... | ..... | 1.78 | ..... | 2.35 | 1.91 | ..... | 2.30 | ..... | 1.66 |

NOTE.—The canal was dry on days when the gage height was not recorded.

*Rating table for Pilot Butte canal near Bend, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.90 | 2 | 1.30 | 7 | 1.70 | 25 | 2.10 | 61 | 2.50 | 145 |
| 1.00 | 2 | 1.40 | 10 | 1.80 | 33 | 2.20 | 77 | 2.60 | 175 |
| 1.10 | 3 | 1.50 | 13 | 1.90 | 41 | 2.30 | 97 | | |
| 1.20 | 5 | 1.60 | 18 | 2.00 | 49 | 2.40 | 120 | | |

NOTE.—The above table is based on discharge measurements made during 1905–6, and is well defined between gage heights 1.7 feet and 2.3 feet.

*Monthly discharge of Pilot Butte canal near Bend, Oreg., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 45 | 0 | 10.0 | 615 |
| February | 45 | 0 | 30.0 | 1,670 |
| March | 45 | 0 | 16.0 | 984 |
| April | 132 | 13 | 50.8 | 3,020 |
| May | 120 | 31 | 79.1 | 4,860 |
| June | 130 | 69 | 100 | 5,950 |
| July | 175 | 108 | 162 | 9,960 |
| August | 181 | 0 | 156 | 9,590 |
| September | 135 | 93 | 133 | 7,910 |
| October | 135 | 19 | 118 | 7,260 |
| November | 77 | 2 | 19.3 | 1,150 |
| December | 43 | 9 | 29.9 | 1,840 |
| The year | 181 | 0 | 75.3 | 54,800 |

NOTE.—Values are rated as fair.

## TUMALO CREEK NEAR LAIDLAW, OREG.

This station was established May 15, 1906. It is located about one-half mile above the head-gate of the Columbia Southern Canal, in sec. 2, T. 18 S., R. 10 E.

The channel is straight; neither bank is liable to overflow, and there is one channel at all stages.

Measurements are made from a footlog. The initial point is a notch cut in the left end of the log.

The gage, which is read voluntarily by G. W. Updike, the ditch tender, is a 1 by 4 inch pine board, graduated with brass tacks, driven in the left bank at the water's edge on the upstream side of the footlog. The bench mark is on top of a fir stump 5 feet from the left bank; elevation, 6.67 feet above the datum of the gage.

*Discharge measurements of Tumalo Creek near Laidlaw, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 15 | I. Landes | 39 | 59 | 2.19 | 218 |
| June 9 | do | 37 | 46 | 1.85 | 144 |
| June 16 | L. R. Allen | 36 | 61 | 2.23 | 236 |
| June 18 | Stevens and Landes | 37 | 55 | 2.08 | 202 |

*Daily gage height, in feet, of Tumalo Creek near Laidlaw, Oreg., for 1906.*

| Day. | May. | June. | July. | Aug. | Sept. | Oct. | Day. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 1.85 | 2.50 | 1.55 | 1.50 | 1.50 | 17 | 2.20 | 2.30 | 1.65 | 1.50 | 1.50 | 1.55 |
| 2 | ..... | 2.10 | 2.65 | 1.55 | 1.50 | 1.65 | 18 | 2.40 | 2.35 | 1.55 | 1.50 | 1.50 | 1.55 |
| 3 | ..... | 2.25 | 2.60 | 1.50 | 1.50 | 1.60 | 19 | 2.50 | 2.40 | 1.65 | 1.50 | 1.50 | 1.52 |
| 4 | ..... | 2.15 | 2.70 | 1.50 | 1.50 | 1.60 | 20 | 2.00 | 2.45 | 1.70 | 1.50 | 1.50 | 1.52 |
| 5 | ..... | 1.95 | 2.60 | 1.50 | 1.50 | 1.55 | 21 | 1.95 | 2.25 | 1.70 | 1.50 | 1.50 | 1.50 |
| 6 | ..... | 1.90 | 2.45 | 1.50 | 1.50 | 1.52 | 22 | 1.90 | 2.20 | 1.65 | 1.50 | 1.50 | 1.50 |
| 7 | ..... | 1.80 | 2.45 | 1.50 | 1.50 | 1.52 | 23 | 1.92 | 2.20 | 1.65 | 1.50 | 1.50 | 1.50 |
| 8 | ..... | 1.85 | 2.40 | 1.55 | 1.50 | 1.52 | 24 | 2.00 | 2.18 | 1.60 | 1.50 | 1.50 | 1.50 |
| 9 | ..... | 1.85 | 2.20 | 1.55 | 1.50 | 1.50 | 25 | 2.50 | 2.60 | 1.60 | 1.50 | 1.50 | 1.55 |
| 10 | ..... | 1.80 | 2.15 | 1.55 | 1.50 | 1.65 | 26 | 1.95 | 2.40 | 1.60 | 1.50 | 1.50 | 2.15 |
| 11 | ..... | 2.10 | 2.15 | 1.55 | 1.50 | 1.85 | 27 | 1.90 | 2.10 | 1.60 | 1.50 | 1.50 | 1.65 |
| 12 | ..... | 2.15 | 2.10 | 1.55 | 1.50 | 1.70 | 28 | 1.95 | 1.90 | 1.60 | 1.50 | 1.50 | 1.60 |
| 13 | ..... | 2.10 | 2.10 | 1.55 | 1.62 | 1.70 | 29 | 1.85 | 2.05 | 1.60 | 1.50 | 1.50 | 1.55 |
| 14 | ..... | 2.00 | 1.95 | 1.55 | 1.58 | 1.67 | 30 | 1.80 | 2.20 | 1.60 | 1.50 | 1.50 | 1.55 |
| 15 | 2.19 | 2.55 | 1.85 | 1.55 | 1.50 | 1.80 | 31 | 1.80 | ..... | 1.60 | 1.50 | ..... | 1.55 |
| 16 | 2.90 | 2.45 | 1.75 | 1.50 | 1.50 | 1.65 | | | | | | | |

*Rating table for Tumalo Creek near Laidlaw, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.50 | 80 | 1.90 | 155 | 2.20 | 230 | 2.50 | 315 | 2.80 | 415 |
| 1.60 | 95 | 2.00 | 180 | 2.30 | 255 | 2.60 | 345 | 2.90 | 450 |
| 1.70 | 115 | 2.10 | 205 | 2.40 | 285 | 2.70 | 380 | 3.00 | 490 |
| 1.80 | 135 | | | | | | | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 4 discharge measurements made during 1906 and is well defined between gage heights 1.7 feet and 2.5 feet.

*Monthly discharge of Tumalo Creek near Laidlaw, Oreg., for 1906.*

[Drainage area, 90 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| May 15–31 | 450 | 135 | 210 | 7,080 | 2.34 | 1.48 |
| June | 345 | 135 | 219 | 13,000 | 2.44 | 2.72 |
| July | 380 | 88 | 182 | 11,200 | 2.01 | 2.32 |
| August | 88 | 80 | 82.6 | 5,080 | .918 | 1.06 |
| September | 99 | 80 | 81.0 | 4,820 | .900 | 1.00 |
| October | 218 | 80 | 98.5 | 6,060 | 1.09 | 1.26 |
| The period | ..... | ..... | ..... | 47,200 | ..... | ..... |

NOTE.—To give the natural flow at this station, the discharge of Wymer canal should be added. Values are rated as good.

## TUMALO CREEK NEAR BEND, OREG.

This station was established October 6, 1906, to take the place of the station on Tumalo Creek near Laidlaw during the winter months when no gage reader is available at the latter place. It is located at the highway bridge on the Bend-Sisters road, about 5 miles from Bend, Oreg.

The channel is straight for 175 feet above and 300 feet below the station. The right bank is high; the left, low. There is a single channel.

The gage, which is read by W. P. Downing, is a pine board attached to the river face of the abutment at the southeast corner of the bridge.

*Discharge measurements of Tumalo Creek near Bend, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 13 | Ivan Landes | 24 | 31 | 1.23 | 53 |
| April 19 | do | 26 | 35 | 1.52 | 80 |
| October 6 | C. L. Swain | ..... | ..... | .40 | [a] 8 |

[a] Estimated.

*Daily gage height, in feet, of Tumalo Creek near Bend, Oreg., for 1906.*

| Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 1.4 | 1.6 | 12 | 0.80 | 1.8 | 1.45 | 23 | 0.35 | 1.4 | 1.65 |
| 2 | ..... | 1.35 | 1.6 | 13 | .52 | 2.9 | 1.5 | 24 | .65 | 1.5 | 1.65 |
| 3 | ..... | 1.4 | 1.5 | 14 | .60 | 3.8 | 1.5 | 25 | .75 | 1.55 | 1.6 |
| 4 | ..... | 1.4 | 1.4 | 15 | .50 | 2.2 | 1.5 | 26 | 2.00 | 1.6 | 1.6 |
| 5 | ..... | 1.4 | 1.45 | 16 | .78 | 1.9 | 1.45 | 27 | .95 | 1.7 | 1.5 |
| 6 | 0.40 | 1.45 | 1.4 | 17 | .32 | 1.75 | 1.4 | 28 | .80 | 1.75 | 1.5 |
| 7 | .40 | 2.2 | 1.3 | 18 | .32 | 1.8 | 1.4 | 29 | .75 | 2.0 | 1.5 |
| 8 | .42 | 2.45 | 1.3 | 19 | .31 | 2.1 | 1.35 | 30 | .75 | 1.9 | 1.45 |
| 9 | .40 | 1 5 | 1.35 | 20 | .30 | 1.5 | 1.35 | 31 | .80 | ..... | 1.6 |
| 10 | .40 | 3.1 | 1.4 | 21 | .32 | 1.5 | 1.5 | | | | |
| 11 | .38 | 1.85 | 1.4 | 22 | .35 | 1.4 | 1.6 | | | | |

## WYMER CANAL NEAR LAIDLAW, OREG.

Wymer canal takes water from Tumalo Creek just above the gaging station on the latter. A gaging station was established on the canal June 16, 1906, in order to determine the total water supply of the creek. It is located just below the headgates.

The bed and banks are of loam and gravel.

Measurements are made from two logs. The gage is a vertical staff and is read by G. W. Updike. The bench mark is on a bench on a fir tree, about 16 inches in diameter, 25 feet below the headgate, and 3 feet from the right bank; elevation, 4.12 feet above the datum of the gage.

*Discharge measurements of Wymer canal near Laidlaw, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| May 15 | I. Landes | 5.5 | 9 | ..... | 12 |
| June 9 | do | 4 | 3.2 | ..... | 8.5 |
| June 16 | L. R. Allen | 16 | 22 | 1.90 | 41 |
| June 18 | Stevens and Landes | 15.5 | 20 | 1.85 | 43 |

*Daily gage height, in feet, of Wymer canal near Laidlaw, Oreg., for 1906.*

| Day. | June. | July. | Aug. | Sept. | Oct. | Day. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 2.05 | 1.00 | 0.88 | 1.00 | 17 | 1.95 | 1.45 | 0.88 | 0.88 | 1.10 |
| 2 | | 2.10 | 1.00 | .88 | 1.30 | 18 | 1.95 | 1.45 | .88 | .88 | 1.10 |
| 3 | | 2.05 | .95 | .88 | 1.20 | 19 | 2.00 | 1.45 | .88 | .88 | 1.10 |
| 4 | | 2.15 | .95 | .88 | 1.10 | 20 | 2.00 | 1.50 | .88 | .88 | 1.10 |
| 5 | | 2.05 | .95 | .88 | 1.10 | 21 | 1.95 | 1.45 | .88 | .88 | 1.05 |
| 6 | | 2.05 | .95 | .88 | 1.06 | 22 | 1.90 | 1.40 | .88 | .88 | 1.05 |
| 7 | | 2.05 | .95 | .88 | 1.06 | 23 | 1.90 | 1.40 | .88 | .88 | 1.10 |
| 8 | | 2.00 | .95 | .88 | 1.04 | 24 | 1.90 | 1.15 | .88 | .88 | 1.15 |
| 9 | | 1.95 | .95 | .88 | 1.02 | 25 | 2.10 | 1.05 | .88 | .88 | 1.20 |
| 10 | | 1.90 | .95 | .88 | | 26 | 2.05 | 1.05 | .88 | .88 | 2.20 |
| 11 | | 1.90 | .95 | .88 | | 27 | 1.95 | 1.05 | .88 | .88 | 1.25 |
| 12 | | 1.90 | .95 | 1.28 | | 28 | 1.85 | 1.05 | .88 | .88 | 1.20 |
| 13 | | 1.90 | .95 | 1.08 | | 29 | 1.90 | 1.05 | .88 | .88 | 1.20 |
| 14 | | 1.75 | .95 | .95 | | 30 | 1.95 | 1.05 | .88 | .88 | 1.15 |
| 15 | | 1.65 | .88 | .88 | | 31 | | 1.05 | .88 | | 1.15 |
| 16 | 1.98 | 1.55 | .88 | .88 | 1.62 | | | | | | |

NOTE.—Water turned out October 10 to 15.

## COLUMBIA SOUTHERN CANAL NEAR LAIDLAW, OREG.

Columbia Southern canal, which is operated by the Columbia Southern Irrigation Company under provisions of the Carey Act, takes water from Tumalo Creek, 15 miles above its mouth. Measurements are made in the flume 1,000 feet below the head-gate. The gage is set with its zero at the bottom of the flume. It is read by G. W. Updike.

*Discharge measurements of Columbia Southern canal near Laidlaw, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 19[a] | I. Landes | 20 | 14 | | 35 |
| May 15 | do | 19.7 | 31.5 | 1.60 | 52 |
| June 9 | do | 19.7 | 35 | 1.78 | 72 |
| June 16 | L. R. Allen | 19.6 | 22 | 1.15 | 22 |
| June 16 | do | 19.6 | 31 | 1.62 | 57 |
| June 18 | Stevens and Landes | 19.7 | 33 | 1.65 | 63 |

[a] Measured 9 miles below the head of the canal.

*Daily gage height, in feet, of Columbia Southern canal near Laidlaw, Oreg., for 1906.*

| Day. | May. | June. | July. | Aug. | Sept. | Oct. | Day. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1.70 | 1.87 | 1.75 | 1.68 | 1.70 | 17 | 1.70 | 1.65 | 2.00 | 1.70 | 1.68 | 1.65 |
| 2 | | 1.75 | 1.87 | 1.75 | 1.68 | 1.70 | 18 | 1.75 | 1.65 | 1.95 | 1.70 | 1.68 | 1.65 |
| 3 | | 1.75 | 1.95 | 1.75 | 1.68 | 1.65 | 19 | 1.75 | 1.65 | 1.95 | 1.70 | 1.68 | 1.65 |
| 4 | | 1.75 | 1.95 | 1.75 | 1.68 | 1.65 | 20 | 1.75 | 1.65 | 1.95 | 1.70 | 1.68 | 1.65 |
| 5 | | 1.75 | 1.95 | 1.75 | 1.68 | 1.65 | 21 | 1.75 | 1.70 | 1.90 | 1.70 | 1.68 | 1.60 |
| 6 | | 1.70 | 2.05 | 1.75 | 1.68 | 1.70 | 22 | 1.75 | 1.70 | 1.90 | 1.70 | 1.68 | 1.60 |
| 7 | | 1.70 | 2.05 | 1.75 | 1.68 | 1.70 | 23 | 1.75 | 1.70 | 1.90 | 1.70 | 1.68 | 1.60 |
| 8 | | 1.70 | 2.05 | 1.75 | 1.68 | 1.70 | 24 | 1.75 | 1.70 | 1.80 | 1.70 | 1.68 | 1.65 |
| 9 | | 1.70 | 2.05 | 1.75 | 1.68 | 1.70 | 25 | 1.75 | 1.80 | 1.80 | 1.70 | 1.70 | 1.65 |
| 10 | | 1.70 | 2.10 | 1.75 | 1.68 | 1.72 | 26 | 1.75 | 1.85 | 1.80 | 1.70 | 1.70 | 1.60 |
| 11 | | 1.70 | 2.10 | 1.75 | 1.68 | 1.72 | 27 | 1.75 | 1.80 | 1.80 | 1.70 | 1.70 | 1.70 |
| 12 | | 1.70 | 2.10 | 1.75 | 1.68 | 1.70 | 28 | 1.75 | 1.80 | 1.80 | 1.70 | 1.70 | 1.65 |
| 13 | | 1.70 | 2.10 | 1.75 | 1.68 | 1.70 | 29 | 1.70 | 1.87 | 1.80 | 1.70 | 1.70 | 1.65 |
| 14 | | 1.70 | 2.10 | 1.75 | 1.68 | 1.70 | 30 | 1.70 | 1.87 | 1.80 | 1.70 | 1.70 | 1.65 |
| 15 | 1.70 | 1.65 | 2.00 | 1.70 | 1.68 | 1.70 | 31 | 1.70 | | 1.80 | 1.70 | | 1.65 |
| 16 | 1.70 | 1.65 | 1.88 | 1.70 | 1.68 | 1.70 | | | | | | | |

*Rating table for Columbia Southern canal near Laidlaw, Oreg., for 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.60 | 55 | 1.80 | 74 | 1.90 | 86 | 2.00 | 99 | 2.10 | 114 |
| 1.70 | 64 | | | | | | | | |

NOTE.—The above table is based on 5 discharge measurements made during 1906 and is fairly well defined.

*Monthly discharge of Columbia Southern canal near Laidlaw, Oreg., for 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| May 15–31 | 69 | 64 | 67.2 | 2,260 |
| June | 82 | 60 | 66.6 | 3,960 |
| July | 114 | 74 | 91.7 | 5,640 |
| August | 69 | 64 | 66.3 | 4,080 |
| September | 64 | 62 | 62.4 | 3,710 |
| October | 66 | 55 | 61.3 | 3,770 |
| The period | | | | 23,400 |

NOTE.—Values are rated as good.

## SQUAW CREEK NEAR SISTERS, OREG.

The station was established June 15, 1906. It is located 4 miles south of Sisters and above all present diversions. McAllister ditch, under construction, has its intake 200 feet above the station.

The channel is straight for 200 feet above and 100 feet below the station. The right bank is high and rocky; the left is low and liable to overflow at extreme high water. The bed of the stream is of firm gravel and is permanent. Changes in a dam 250 feet below will change the rating.

Measurements are made from a foot log.

Gage heights are furnished jointly by the Squaw Creek Irrigation Company and citizens of Sisters. The gage is vertical, and nailed to an alder tree on the right bank, about 3 feet above the foot log. The bench mark is the highest point of the sawed part of a pine stump 30 feet to the left and 10 feet upstream from the point of measurement; elevation, 10.27 feet above the datum of the gage.

*Discharge measurements of Squaw Creek near Sisters, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq.-ft.* | *Feet.* | *Sec.-ft.* |
| April 17 | I. Landes | 31 | 48 | 3.65 | 106 |
| June 8 | L. R. Allen | 31 | 46 | 3.53 | 105 |
| June 8 | I. Landes | 31 | 49 | 3.60 | 114 |
| June 15 | J. H. Lewis and L. R. Allen | 32 | 65 | 4.09 | 205 |
| September 22 | C. W. Allen | 31 | 38 | 3.55 | 110 |

*Daily gage height, in feet, of Squaw Creek near Sisters, Oreg., for 1906.*

| Day. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Day. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.3 | 3.75 | 3.6 | 3.6 | 3.1 | 3.0 | 17 | 4.1 | 3.65 | 3.25 | 3.35 | 2.1 | 1.7 |
| 2 | 4.2 | 3.7 | 3.6 | 3.65 | 3.1 | 1.8 | 18 | 4.0 | 3.65 | 3.35 | 3.3 | 2.0 | 1.65 |
| 3 | 4.4 | 3.72 | 3.5 | 3.65 | 3.1 | 1.6 | 19 | 2.25 | 3.6 | 3.4 | 3.3 | 1.95 | 1.6 |
| 4 | 4.95 | 3.7 | 3.55 | 3.65 | 3.1 | 1.6 | 20 | 4.05 | 3.6 | 3.45 | 3.3 | 1.9 | 2.3 |
| 5 | 4.6 | 3.8 | 3.55 | 3.3 | 3.1 | 1.6 | 21 | 4.1 | 3.5 | 3.45 | 3.3 | 1.8 | 2.05 |
| 6 | 4.6 | 4.0 | 3.75 | 3.35 | 3.15 | 1.6 | 22 | 4.2 | 3.5 | 3.55 | 3.3 | 1.8 | 2.0 |
| 7 | 4.55 | 4.0 | 3.8 | 3.3 | 5.25 | 3.0 | 23 | 4.2 | 3.55 | 3.4 | 3.35 | 1.8 | 1.9 |
| 8 | 4.5 | 3.85 | 4.1 | 3.35 | 4.1 | 1.7 | 24 | 3.8 | 3.55 | 3.35 | 3.35 | 1.8 | 1.95 |
| 9 | 4.3 | 3.8 | 3.6 | 3.3 | 3.05 | 1.75 | 25 | 3.85 | 3.55 | 3.35 | 3.35 | 1.7 | 2.1 |
| 10 | 4.5 | 4.0 | 3.5 | 3.45 | 5.7 | 1.7 | 26 | 3.75 | 3.55 | 3.3 | 4.0 | 1.7 | 2.0 |
| 11 | 4.55 | 3.9 | 3.45 | 3.4 | 3.4 | 1.7 | 27 | 4.0 | 3.6 | 3.3 | 3.55 | 1.7 | 1.9 |
| 12 | 4.9 | 4.0 | 3.45 | 3.35 | 3.2 | 1.75 | 28 | 4.2 | 3.6 | 3.3 | 3.35 | 3.5 | 1.9 |
| 13 | 4.52 | 3.95 | 3.4 | 3.3 | 4.2 | 2.9 | 29 | 3.95 | 3.5 | 3.4 | 3.3 | 3.0 | 1.8 |
| 14 | 4.4 | 3.8 | 3.3 | 3.3 | 4.5 | 1.7 | 30 | 3.9 | 3.6 | 3.4 | 3.2 | 2.05 | 1.8 |
| 15 | 4.35 | 3.9 | 3.3 | 3.3 | 3.0 | 1.7 | 31 | 3.85 | 3.5 | ..... | 3.2 | ..... | 1.75 |
| 16 | 4.1 | 3.75 | 3.25 | 3.3 | 2.4 | 1.75 | | | | | | | |

NOTE.—Conditions were changed early in November by washing out of dam below; this was replaced November 28, and washed out again December 3. Ice jam December 1 and 13.

*Rating table for Squaw Creek near Sisters, Oreg., from July 1 to October 31, 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 3.20 | 67 | 3.60 | 113 | 4.00 | 185 | 4.40 | 282 | 4.80 | 405 |
| 3.30 | 77 | 3.70 | 128 | 4.10 | 207 | 4.50 | 310 | 4.90 | 440 |
| 3.40 | 88 | 3.80 | 145 | 4.20 | 231 | 4.60 | 340 | 5.00 | 475 |
| 3.50 | 100 | 3.90 | 164 | 4.30 | 256 | 4.70 | 372 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 5 discharge measurements made during 1906 and it is not well defined.

*Monthly discharge of Squaw Creek near Sisters, Oreg., for 1906.*

[Drainage area, 90 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| July | 458 | 136 | 251 | 15,400 | 2.79 | 3.22 |
| August | 185 | 100 | 133 | 8.180 | 1.48 | 1.71 |
| September | 207 | 72 | 97.9 | 5,830 | 1.09 | 1.22 |
| October | 185 | 67 | 88.3 | 5,400 | .981 | 1.13 |
| The period | ..... | ..... | ..... | 34,800 | ..... | ..... |

NOTE.—Values, July to October, are rated as fair.

### MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in Deschutes River drainage basin in 1906:

*Miscellaneous measurements in Deschutes River drainage basin, Oregon, in 1906.*

| Date. | Stream. | Locality. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|
| | | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| January 9 | Crooked River | Forest | 50 | 78 | [a] 27.43 | 75 |
| April 16 | do | do | 135 | 967 | [a] 18.71 | 3,940 |
| May 16 | do | do | 84 | 189 | [a] 25.44 | 326 |
| June 17 | do | do | 100 | 395 | [a] 23.94 | 773 |
| October 14 | do | do | 22 | 65 | [a] 24.62 | 84 |
| April 18[b] | Deschutes Irrigation and Power Company's flume. | Near Bend | 14.9 | 15 | ..... | 83 |
| January 10 | Deschutes River | Sec. 36, T. 14 S. R. 12 E. | 145 | 481 | ..... | 1,350 |
| October 13[c] | do | do | 138 | 458 | ..... | 1,230 |
| September 2[d] | do | Moro | 260 | 1,120 | 1.35 | 5,040 |
| October 17[d] | do | do | 260 | 1,130 | 1.40 | 5.520 |
| October 18 | do | Warm Springs Ferry | 170 | 1,690 | [e] 5.40 | 4,780 |
| June 8 | McAllister ditch | Sisters | 7 | 5 | ..... | 6.9 |
| June 15 | do | do | 7 | 5.2 | ..... | 6.6 |
| October 17 | Metolius River | Near mouth | ..... | ..... | ..... | [f] 2,800 |
| January 6 | Ochoco Creek | Prineville | 9 | 4.4 | [g] 5.88 | 4.6 |
| April 16 | do | do | 71 | 97 | [g] 4.55 | 286 |
| May 17 | do | do | 14 | 10 | [g] 5.76 | 35 |
| June 7 | do | do | 44 | 68 | [g] 4.87 | 148 |
| June 13 | Pole Creek | Sisters | 8 | 4.2 | ..... | 6.2 |
| October 15 | Shitike | Warm Springs Agency | 26 | 29 | [h] | 61 |
| June 10 | Swalley canal | Bend, intake flume | 7 | 6 | ..... | 13 |
| June 20 | do | Bend, below intake flume | 13 | 10 | ..... | 12 |
| June 20 | do | Bend, 5 miles below head | 8 | 5 | ..... | 6.5 |
| October 19 | Warm Springs | Warm Springs Agency | 92 | 433 | [h] | 260 |
| October 20 | White River | Tygh Valley | 56 | 56 | [h] | 165 |

[a] Below nail in top of floor sill on downstream side of east end of bridge.
[b] Just below headgate; contains discharge of Pilot Butte and Central Oregon canals.
[c] At Tetherow bridge; water surface 4.35 feet below cross cut in northeast corner of bridge on top of abutment.
[d] At Free Bridge gaging station, discontinued December 31, 1899; see Water-Supply Paper No. 38, p. 377, 378.
[e] Below point on alder stump on west bank.
[f] Estimated.
[g] Below reference point on bridge.
[h] Low water.

## HOOD RIVER DRAINAGE BASIN.

### HOOD RIVER AT WINANS, OREG.

Hood River has its source in the glaciers on the northern slope of Mount Hood, flows north, and unites with Columbia River at the town of Hood River. Its drainage area is wholly mountainous and timbered except where the timber has been removed. A large percentage of its forested area has been burned. The waters of this stream and its tributaries are used for irrigation and power development. The table-lands bordering the river have been cleared of timber and are irrigated by high-line canals. The agricultural products of the district are fruit and berries.

This station was established November 17, 1905. It is located 300 feet below the junction of the main forks of the river at Winans, 10½ miles above Hood River post-office, Oreg. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 219, where are given also references to publications that contain data for previous years.

*Discharge measurements of Hood River at Winans, Oreg., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| 1905. | | | | | |
| November 17 | L. R. Allen | 90 | 147 | 0.57 | 493 |
| December 23 | do | 90 | 180 | 1.03 | 767 |
| 1906. | | | | | |
| March 9 | P. A. Cupper | 99 | 298 | 1.90 | 1,360 |
| May 22 [a] | L. R. Allen | 93 | 188 | 1.31 | 702 |
| July 8 | do | 97 | 259 | 1.52 | 1,160 |
| August 29 | do | 91 | 191 | .77 | 571 |
| October 20 | J. C. Stevens | 95 | 224 | 1.17 | 899 |
| December 15 | H. McGlashan | 94 | 253 | 1.20 | 864 |

[a] Not reliable, as débris was lodged against gage.

*Daily gage height, in feet, of Hood River at Winans, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.9 | 1.6 | 1.8 | 1.9 | 2.0 | 1.3 | 1.5 | 1.0 | 0.7 | 0.7 | 1.3 | 1.1 |
| 2 | 1.0 | 1.6 | 1.7 | 1.8 | 2.0 | 1.3 | 1.5 | 1.0 | .7 | .7 | 1.0 | 1.2 |
| 3 | 1.0 | 1.5 | 1.6 | 1.7 | 1.9 | 1.4 | 1.6 | 1.0 | .7 | .7 | .9 | 1.3 |
| 4 | 1.0 | 1.5 | 1.6 | 1.6 | 1.9 | 1.4 | 1.6 | 1.0 | .7 | .7 | .9 | 1.3 |
| 5 | 1.1 | 1.4 | 1.5 | 1.9 | 1.9 | 1.4 | 1.7 | 1.0 | .7 | .7 | .9 | 1.4 |
| 6 | 1.2 | 1.4 | 1.6 | 2.0 | 1.9 | 1.5 | 1.7 | 1.0 | .7 | .7 | .8 | 1.4 |
| 7 | 1.3 | 1.3 | 1.7 | 2.4 | 1.9 | 1.5 | 1.7 | 1.0 | .7 | .7 | .8 | 1.5 |
| 8 | 1.3 | 1.2 | 1.9 | 2.4 | 1.8 | 1.6 | 1.6 | 1.0 | .7 | .7 | .8 | 1.5 |
| 9 | 1.4 | 1.1 | 1.9 | 2.2 | 1.8 | 1.6 | 1.5 | 1.0 | .7 | .7 | .8 | 1.5 |
| 10 | 1.5 | 1.1 | 1.8 | 2.1 | 1.8 | 1.6 | 1.4 | 1.0 | .7 | .7 | .9 | 1.4 |
| 11 | 1.1 | 1.0 | 1.6 | 2.0 | 1.7 | 1.6 | 1.3 | 1.0 | .7 | 2.0 | 2.5 | 1.4 |
| 12 | 1.1 | 1.0 | 1.6 | 1.9 | 1.7 | 1.6 | 1.3 | 1.0 | .7 | 2.2 | 4.5 | 1.3 |
| 13 | 1.1 | 1.0 | 1.6 | 1.9 | 1.7 | 1.7 | 1.3 | 1.0 | .7 | 2.0 | 6.4 | 1.2 |
| 14 | 1.0 | 1.0 | 1.6 | 1.8 | 1.7 | 1.8 | 1.3 | 1.0 | 1.2 | 2.0 | 6.5 | 1.2 |
| 15 | 1.0 | 1.0 | 1.5 | 1.8 | 1.7 | 1.8 | 1.3 | 1.0 | 1.3 | 1.9 | 6.4 | 1.2 |
| 16 | 1.1 | 1.0 | 1.5 | 1.8 | 1.6 | 2.0 | 1.3 | 0.9 | 1.0 | 1.8 | 3.7 | 1.2 |
| 17 | 1.2 | 1.3 | 1.5 | 1.9 | 1.6 | 1.9 | 1.3 | .9 | .7 | 1.7 | 3.4 | 1.3 |
| 18 | 1.3 | 3.0 | 1.6 | 1.9 | 1.5 | 1.7 | 1.3 | .9 | .6 | 1.5 | 2.7 | 1.4 |
| 19 | 1.0 | 3.0 | 1.6 | 2.0 | 1.5 | 1.7 | 1.3 | .8 | .7 | 1.4 | 2.4 | 1.6 |
| 20 | .9 | 3.0 | 1.5 | 2.1 | 1.5 | 1.7 | 1.3 | .8 | .7 | 1.4 | 2.2 | 6.6 |
| 21 | .9 | 2.9 | 1.5 | 2.2 | 1.5 | 1.6 | 1.3 | .8 | .7 | 1.4 | 2.0 | 4.6 |
| 22 | 1.2 | 2.8 | 1.5 | 2.2 | 1.4 | 1.6 | 1.2 | .7 | .7 | 1.4 | 2.0 | 3.6 |
| 23 | 1.4 | 2.4 | 1.5 | 2.1 | 1.4 | 1.6 | 1.2 | .7 | .7 | 2.0 | 1.8 | 3.6 |
| 24 | 2.9 | 2.3 | 1.5 | 2.0 | 1.4 | 1.6 | 1.1 | .7 | .7 | 2.0 | 1.7 | 3.4 |
| 25 | 2.0 | 2.2 | 1.5 | 2.0 | 1.5 | 1.6 | 1.1 | .7 | .7 | 1.9 | 1.5 | 3.3 |
| 26 | 1.8 | 2.2 | 1.5 | 2.0 | 1.5 | 1.6 | 1.0 | .7 | .7 | 1.8 | 1.5 | 3.0 |
| 27 | 1.8 | 2.0 | 1.5 | 2.0 | 1.5 | 1.6 | .9 | .7 | .7 | 1.8 | 1.4 | 2.4 |
| 28 | 1.6 | 1.9 | 1.5 | 2.0 | 1.5 | 1.6 | .9 | .7 | .7 | 1.7 | 1.4 | 2.2 |
| 29 | 1.7 | ..... | 1.6 | 2.0 | 1.4 | 1.6 | 1.0 | .7 | .7 | 1.6 | 1.2 | 2.2 |
| 30 | 1.7 | ..... | 2.0 | 2.0 | 1.4 | 1.6 | 1.0 | .7 | .7 | 1.5 | 1.2 | 2.2 |
| 31 | 1.7 | ..... | 2.5 | ..... | 1.4 | ..... | 1.0 | .7 | ..... | 1.4 | ..... | 2.2 |

NOTE.—From March to June there was more or less backwater, caused by débris. The flow is influenced by logging dams on the east fork, about 2 miles above the station. These gage heights represent only approximately the daily means.

*Rating table for Hood River at Winans, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.50 | 430 | 1.10 | 835 | 1.70 | 1,325 | 2.30 | 1,875 | 2.90 | 2,460 |
| 0.60 | 490 | 1.20 | 910 | 1.80 | 1,415 | 2.40 | 1,970 | 3.00 | 2,560 |
| 0.70 | 555 | 1.30 | 990 | 1.90 | 1,505 | 2.50 | 2,065 | 4.00 | 3,560 |
| 0.80 | 620 | 1.40 | 1,070 | 2.00 | 1,595 | 2.60 | 2,160 | 5.00 | 4,660 |
| 0.90 | 690 | 1.50 | 1,155 | 2.10 | 1,685 | 2.70 | 2,260 | 6.00 | 5,860 |
| 1.00 | 760 | 1.60 | 1,240 | 2.20 | 1,780 | 2.80 | 2,360 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 6 discharge measurements made during 1905–6 and is well defined between gage heights 0.5 foot and 1.5 feet. Above gage height 2.0 feet it becomes uncertain, and for the highest stages is only approximate.

*Monthly discharge of Hood River at Winans, Oreg., for 1905–6.*

[Drainage area, 370 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| November 19–30 | 1,160 | 555 | 709 | 16,900 | 1.92 | .857 |
| December | 1,420 | 555 | 804 | 49,400 | 2.17 | 2.50 |
| The period | | | | 66,300 | | |
| 1906. | | | | | | |
| January | 2,460 | 690 | 1,030 | 63,300 | 2.78 | 3.20 |
| February | 2,560 | 760 | 1,400 | 77,800 | 3.78 | 3.94 |
| March | 2,060 | 1,150 | 1,280 | 78,700 | 3.46 | 3.99 |
| April | 1,970 | 1,240 | 1,590 | 94,600 | 4.30 | 4.80 |
| May | 1,600 | 1,070 | 1,280 | 78,700 | 3.46 | 3.99 |
| June | 1,600 | 990 | 1,240 | 73,800 | 3.35 | 3.74 |
| July | 1,320 | 690 | 1,000 | 61,500 | 2.70 | 3.11 |
| August | 760 | 555 | 674 | 41,400 | 1.82 | 2.10 |
| September | 990 | 490 | 586 | 34,900 | 1.58 | 1.76 |
| October | 1,780 | 555 | 1,100 | 67,600 | 2.97 | 3.42 |
| November | 6,460 | 620 | 1,890 | 112,000 | 5.11 | 5.70 |
| December | 6,580 | 835 | 1,740 | 107,000 | 4.70 | 5.42 |
| The year | 6,580 | 490 | 1,230 | 891,000 | 3.33 | 45.17 |

NOTE.—Values are rated as follows: March to June, 1906, approximate; remainder of 1905 and 1906, good. Débris caused backwater to a greater or less extent.

## WILLAMETTE RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Willamette River is formed by the junction of Middle and Coast forks near Eugene, Oreg., from which point it flows in a general northerly direction to its point of junction with the Columbia, about 10 miles north of Portland. Coast Fork rises in the eastern slope of the Coast Range and Middle Fork on the western slope of the Cascade Mountains. The tributaries of this stream flow both east and west, draining heavily timbered mountain areas. Many of them afford extensive power possibilities. At present the development in this line is in the primitive state. The natural resources of the Willamette Valley would make it an unrivaled manufacturing center. There is unlimited water power, an abundance of raw material, and adequate transportation facilities. The principal tributaries of this stream are the McKenzie, Santiam, Luckiamute, Molalla, Yamhill, and Clackamas rivers.

### WILLAMETTE RIVER AT ALBANY, OREG.

This station was established July 21, 1905. It is located at the Corvallis and Eastern Railroad bridge at Albany, Oreg., just above the mouth of Calipooia Creek and 7 miles above the mouth of Santiam River. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 223.

*Discharge measurements of Willamette River at Albany, Oreg., in 1905–1907.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| July 20 | L. R. Allen | | 3,720 | 3.29 | 3,430 |
| 1906. | | | | | |
| January 6 | L. R. Allen | 438 | 5,160 | 6.56 | 13,400 |
| February 8 | do | 439 | 4,860 | 5.84 | 11,700 |
| March 28 | do | 438 | 4,900 | 6.12 | 13,300 |
| May 9 | do | 433 | 4,380 | 5.10 | 9,380 |
| July 25 | do | 428 | 3,610 | 2.92 | 4,360 |
| September 5 | I. E. Oakes | 425 | 3,580 | 2.20 | 2,960 |
| 1907. | | | | | |
| February 5 | I. E. Oakes | 2,960 | 38,500 | 27.55 | 146,000 |

*Daily gage height, in feet, of Willamette River at Albany, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9.3 | 7.5 | 12.7 | 7.9 | 6.05 | 7.8 | 4.45 | 2.8 | 2.4 | 2.35 | 3.1 | 5.05 |
| 2 | 8.8 | 7.45 | 10.5 | 8.3 | 5.85 | 6.9 | 4.25 | 2.75 | 2.35 | 2.3 | 2.95 | 4.8 |
| 3 | 7.4 | 7.15 | 9.4 | 7.55 | 5.75 | 6.5 | 4.2 | 2.7 | 2.3 | 2.3 | 2.9 | 4.65 |
| 4 | 6.8 | 7.05 | 8.7 | 6.98 | 5.55 | 6.3 | 4.1 | 2.7 | 2.3 | 2.35 | 2.95 | 4.4 |
| 5 | 6.75 | 6.75 | 8.25 | 6.68 | 5.5 | 6.8 | 3.95 | 2.7 | 2.2 | 2.4 | 3.15 | 4.5 |
| 6 | 6.55 | 6.55 | 7.75 | 6.48 | 5.4 | 6.55 | 3.8 | 2.6 | 2.2 | 2.4 | 3.35 | 4.5 |
| 7 | 6.5 | 6.2 | 7.6 | 6.28 | 5.25 | 6.7 | 3.75 | 2.6 | 2.2 | 2.4 | 3.9 | 4.7 |
| 8 | 6.4 | 5.8 | 7.5 | 6.18 | 5.05 | 7.1 | 3.7 | 2.6 | 2.2 | 2.4 | 6.9 | 5.6 |
| 9 | 6.75 | 5.75 | 7.5 | 6.08 | 5.1 | 6.9 | 3.7 | 2.6 | 2.2 | 2.3 | 9.3 | 6.6 |
| 10 | 8.3 | 5.6 | 7.45 | 6.3 | 5.0 | 7.3 | 3.55 | 2.6 | 2.2 | 2.3 | 7.6 | 7.1 |
| 11 | 8.1 | 5.5 | 7.4 | 6.05 | 5.1 | 7.2 | 3.3 | 2.6 | 2.1 | 2.35 | 7.2 | 7.5 |
| 12 | 8.3 | 5.35 | 7.25 | 5.8 | 5.1 | 6.9 | 3.3 | 2.6 | 2.15 | 2.4 | 7.1 | 7.55 |
| 13 | 9.0 | 5.2 | 6.7 | 5.55 | 5.0 | 6.65 | 3.3 | 2.55 | 2.2 | 2.45 | 6.9 | 6.8 |
| 14 | 10.25 | 5.1 | 6.4 | 5.35 | 4.9 | 6.5 | 3.25 | 2.5 | 2.3 | 2.65 | 8.4 | 6.45 |
| 15 | 10.2 | 4.85 | 6.15 | 5.25 | 5.0 | 6.3 | 3.2 | 2.5 | 2.3 | 2.7 | 10.95 | 6.2 |
| 16 | 10.3 | 5.05 | 5.75 | 5.25 | 5.7 | 6.6 | 3.2 | 2.5 | 2.5 | 2.9 | 12.35 | 6.65 |
| 17 | 13.0 | 5.15 | 5.55 | 5.3 | 5.75 | 7.4 | 3.1 | 2.5 | 2.8 | 3.45 | 13.1 | 8.15 |
| 18 | 15.0 | 5.75 | 5.38 | 5.2 | 5.4 | 7.05 | 3.1 | 2.5 | 2.9 | 4.6 | 12.9 | 7.35 |
| 19 | 13.0 | 7.05 | 5.32 | 5.08 | 5.2 | 6.6 | 3.1 | 2.5 | 2.75 | 4.65 | 13.05 | 7.3 |
| 20 | 11.8 | 9.85 | 5.42 | 4.92 | 5.1 | 6.5 | 3.1 | 2.5 | 2.65 | 4.3 | 10.7 | 8.8 |
| 21 | 9.8 | 11.6 | 5.72 | 5.42 | 5.1 | 5.8 | 3.1 | 2.6 | 2.6 | 4.05 | 9.35 | 11.4 |
| 22 | 8.85 | 13.25 | 6.2 | 5.25 | 5.35 | 5.55 | 3.0 | 2.6 | 2.4 | 3.7 | 9.25 | 10.95 |
| 23 | 8.15 | 12.55 | 6.32 | 5.4 | 5.8 | 5.3 | 3.0 | 2.6 | 2.4 | 3.4 | 8.9 | 9.8 |
| 24 | 9.6 | 12.85 | 6.25 | 5.22 | 5.9 | 5.1 | 3.0 | 2.65 | 2.5 | 3.25 | 8.0 | 9.85 |
| 25 | 10.6 | 14.8 | 6.18 | 5.5 | 5.7 | 4.9 | 2.9 | 2.8 | 2.5 | 3.2 | 7.1 | 9.45 |
| 26 | 10.25 | 15.1 | 6.08 | 5.68 | 5.6 | 4.6 | 2.9 | 2.95 | 2.6 | 3.1 | 6.55 | 10.65 |
| 27 | 9.4 | 13.9 | 6.1 | 5.95 | 5.6 | 4.5 | 2.85 | 2.75 | 2.55 | 2.9 | 6.2 | 11.45 |
| 28 | 8.55 | 13.5 | 6.22 | 5.9 | 5.55 | 4.5 | 2.8 | 2.6 | 2.5 | 3.3 | 5.85 | 10.5 |
| 29 | 8.1 | ..... | 6.42 | 6.4 | 7.2 | 4.55 | 2.8 | 2.5 | 2.5 | 3.25 | 5.55 | 9.4 |
| 30 | 7.65 | ..... | 5.8 | 6.25 | 9.95 | 4.55 | 2.8 | 2.5 | 2.4 | 3.15 | 5.25 | 8.5 |
| 31 | 7.5 | ..... | 6.1 | ..... | 8.9 | ..... | 2.8 | 2.4 | ..... | 3.1 | ..... | 8.4 |

*Rating tables for Willamette River at Albany, Oreg.*

1905.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.00 | 1,755 | 2.90 | 2,835 | 3.80 | 4,320 | 4.70 | 6,260 | 6.20 | 10,300 |
| 2.10 | 1,855 | 3.00 | 2,980 | 3.90 | 4,510 | 4.80 | 6,500 | 6.40 | 10,910 |
| 2.20 | 1,960 | 3.10 | 3,130 | 4.00 | 4,710 | 4.90 | 6,750 | 6.60 | 11,530 |
| 2.30 | 2,070 | 3.20 | 3,385 | 4.10 | 4,910 | 5.00 | 7,000 | 6.80 | 12,160 |
| 2.40 | 2,185 | 3.30 | 3,445 | 4.20 | 5,120 | 5.20 | 7,500 | 7.00 | 12,800 |
| 2.50 | 2,305 | 3.40 | 3,610 | 4.30 | 5,340 | 5.40 | 8,020 | 8.00 | 16,000 |
| 2.60 | 2,430 | 3.50 | 3,780 | 4.40 | 5,560 | 5.60 | 8,560 | 9.00 | 19,400 |
| 2.70 | 2,560 | 3.60 | 3,955 | 4.50 | 5,790 | 5.80 | 9,120 | | |
| 2.80 | 2,695 | 3.70 | 4,135 | 4.60 | 6,020 | 6.00 | 9,700 | | |

[a] This table is applicable only for open-channel conditions. It is based on one discharge measurement made during 1905 and the form of the 1906 curve and is not well defined.

*Rating tables for Willamette River at Albany, Oreg.*—Continued.

1906.[a]

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.00 | 2,670 | 3.10 | 4,730 | 4.20 | 7,240 | 5.60 | 11,010 | 7.80 | 18,060 |
| 2.10 | 2,810 | 3.20 | 4,950 | 4.30 | 7,480 | 5.80 | 11,600 | 8.00 | 18,800 |
| 2.20 | 2,960 | 3.30 | 5,170 | 4.40 | 7,730 | 6.00 | 12,200 | 9.00 | 22,700 |
| 2.30 | 3,120 | 3.40 | 5,390 | 4.50 | 7,980 | 6.20 | 12,800 | 10.00 | 27,000 |
| 2.40 | 3,290 | 3.50 | 5,610 | 4.60 | 8,230 | 6.40 | 13,410 | 11.00 | 31,600 |
| 2.50 | 3,470 | 3.60 | 5,840 | 4.70 | 8,490 | 6.60 | 14,030 | 12.00 | 36,400 |
| 2.60 | 3,660 | 3.70 | 6,070 | 4.80 | 8,760 | 6.80 | 14,660 | 13.00 | 41,300 |
| 2.70 | 3,860 | 3.80 | 6,300 | 4.90 | 9,030 | 7.00 | 15,300 | 14.00 | 46,700 |
| 2.80 | 4,070 | 3.90 | 6,530 | 5.00 | 9,300 | 7.20 | 15,960 | 15.00 | 52,200 |
| 2.90 | 4,290 | 4.00 | 6,760 | 5.20 | 9,860 | 7.40 | 16,640 | | |
| 3.00 | 4,510 | 4.10 | 7,000 | 5.40 | 10,430 | 7.60 | 17,340 | | |

[a] This table is applicable only for open-channel conditions. It is based on 6 discharge measurements made during 1906 and 1 during 1907 and is well defined between gage heights 2.2 feet and 6.5 feet.

*Monthly discharge of Willamette River at Albany, Oreg., for 1905–6.*

[Drainage area, 4,860 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| September | 2,560 | 1,800 | 2,020 | 120,000 | 0.416 | 0.46 |
| October[a] | 6,750 | 2,700 | 3,750 | 231,000 | .772 | .89 |
| November[a] | 5,900 | 2,430 | 3,450 | 205,000 | .710 | .79 |
| December | 18,700 | 4,910 | 9,650 | 593,000 | 1.99 | 2.29 |
| The period | | | | 1,150,000 | | |
| 1906. | | | | | | |
| January | 52,200 | 13,400 | 23,600 | 1,450,000 | 4.86 | 5.60 |
| February | 52,800 | 8,900 | 21,900 | 1,220,000 | 4.51 | 4.70 |
| March | 39,800 | 10,200 | 15,700 | 965,000 | 3.23 | 3.72 |
| April | 19,900 | 9,080 | 12,200 | 726,000 | 2.51 | 2.80 |
| May | 26,800 | 9,030 | 11,500 | 707,000 | 2.37 | 2.73 |
| June | 18,100 | 7,980 | 12,900 | 768,000 | 2.65 | 2.96 |
| July | 7,860 | 4,070 | 5,260 | 323,000 | 1.08 | 1.24 |
| August | 4,400 | 3,290 | 3,680 | 226,000 | .757 | .87 |
| September | 4,290 | 2,810 | 3,320 | 198,000 | .683 | .76 |
| October | 8,360 | 3,120 | 4,530 | 279,000 | .932 | 1.07 |
| November | 41,800 | 4,290 | 18,200 | 1,080,000 | 3.74 | 4.17 |
| December | 33,800 | 7,730 | 18,200 | 1,120,000 | 3.74 | 4.31 |
| The year | 52,800 | 2,810 | 12,600 | 9,060,000 | 2.59 | 34.93 |

[a] Gage heights published in Water-Supply Paper No. 178 as 2.11 feet should be 2.9 feet, 3.11 should be 3.9, and 2.1 should be 2.8.

NOTE.—Values are rated as follows: September, 1905, to February, 1906, fair; March to December, 1906, good.

## MIDDLE FORK OF WILLAMETTE RIVER AT JASPER, OREG.

This station was established September 16, 1905. It is located at Jasper Ferry, Jasper post-office, Oreg., 2 miles above Natron and 3 miles below the mouth of Fall Creek. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 220.

*Discharge measurements of Middle Fork of Willamette River at Jasper, Oreg., in 1905–1907.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| September 16 | L. R. Allen | 322 | 652 | 1.25 | 758 |
| December 29 | do | 354 | 1,370 | 3.27 | 3,920 |
| 1906. | | | | | |
| February 3 | L. R. Allen | 368 | 1,590 | 3.87 | 5,530 |
| March 23 | do | 357 | 1,400 | [a] 3.38 | 3,890 |
| May 5 | do | 356 | 1,420 | [a] 3.52 | 5,280 |
| August 17 | do | 325 | 726 | 1.48 | 953 |
| September 17 | I. E. Oakes | 327 | 807 | 1.70 | 1,130 |
| 1907. | | | | | |
| January 30 | do | 396 | 2,730 | 7.10 | 21,100 |

[a] Affected by log jam.

*Daily gage height, in feet, of Middle Fork of Willamette River at Jasper, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.6 | 3.8 | 4.4 | 4.6 | 3.6 | 4.0 | 2.6 | 1.7 | 1.4 | 1.4 | 1.6 | 2.5 |
| 2 | 3.1 | 3.8 | 4.1 | 4.2 | 3.5 | 3.9 | 2.6 | 1.7 | 1.4 | 1.4 | 1.6 | 2.5 |
| 3 | 3.1 | 3.9 | 4.0 | 4.1 | 3.5 | 3.8 | 2.5 | 1.6 | 1.4 | 1.5 | 1.6 | 2.4 |
| 4 | 3.1 | 3.7 | 3.9 | 3.8 | 3.4 | 4.1 | 2.5 | 1.6 | 1.4 | 1.9 | 1.6 | 2.3 |
| 5 | 3.0 | 3.6 | 3.7 | 3.7 | 3.4 | 4.0 | 2.5 | 1.7 | 1.4 | 1.5 | 2.0 | 2.4 |
| 6 | 3.2 | 3.6 | 3.7 | 3.6 | 3.3 | 4.1 | 2.4 | 1.6 | 1.4 | 1.5 | 2.0 | 2.7 |
| 7 | 3.2 | 3.4 | 3.8 | 3.6 | 3.3 | 4.4 | 2.3 | 2.0 | 1.4 | 1.5 | 3.3 | 2.7 |
| 8 | 3.3 | 3.3 | 3.9 | 3.5 | 3.2 | 4.3 | 2.2 | 1.8 | 1.4 | 1.4 | 4.6 | 3.6 |
| 9 | 4.6 | 3.2 | 4.0 | 3.7 | 3.2 | 4.4 | 2.1 | 2.0 | 1.5 | 1.4 | 3.7 | 3.6 |
| 10 | 4.3 | 3.1 | 4.1 | 3.6 | 3.4 | 4.5 | 2.1 | 2.2 | 1.5 | 1.4 | 3.2 | 3.6 |
| 11 | 4.0 | 3.0 | 3.9 | 3.4 | 3.5 | 4.2 | 2.0 | 2.2 | 1.4 | 1.4 | 3.7 | 3.7 |
| 12 | 4.2 | 2.9 | 3.7 | 3.2 | 3.3 | 4.1 | 2.0 | 2.3 | 1.5 | 1.5 | 3.2 | 3.5 |
| 13 | 4.5 | 2.8 | 3.5 | 3.2 | 3.2 | 4.0 | 2.0 | 2.0 | 2.2 | 1.7 | 4.1 | 3.2 |
| 14 | 4.2 | 2.8 | 3.3 | 3.1 | 3.1 | 3.8 | 1.9 | 2.2 | 1.9 | 1.6 | 4.9 | 3.1 |
| 15 | 4.1 | 2.8 | 3.2 | 3.0 | 3.6 | 3.7 | 1.9 | 1.5 | 2.4 | 1.6 | 5.6 | 3.0 |
| 16 | 6.3 | 2.9 | 3.0 | 3.0 | 3.4 | 4.4 | 1.9 | 1.5 | 2.0 | 2.2 | 6.1 | 4.4 |
| 17 | 5.9 | 3.1 | 2.9 | 3.1 | 3.2 | 4.2 | 2.0 | 1.5 | 1.7 | 2.9 | 5.9 | 4.0 |
| 18 | 4.9 | 3.4 | 2.8 | 3.0 | 3.0 | 3.9 | 1.8 | 1.5 | 1.6 | 2.7 | 6.0 | 3.7 |
| 19 | 4.2 | 5.1 | 2.8 | 2.9 | 2.9 | 3.6 | 1.8 | 1.5 | 1.5 | 2.6 | 4.8 | 4.4 |
| 20 | 4.0 | 5.05 | 2.8 | 2.9 | 2.9 | 3.5 | 1.8 | 1.5 | 1.5 | 2.2 | 4.2 | 5.7 |
| 21 | 3.5 | 5.4 | 3.0 | 2.9 | 3.2 | 3.3 | 1.7 | 1.4 | 1.5 | 2.1 | 4.5 | 5.3 |
| 22 | 3.4 | 5.1 | 3.2 | 3.0 | 3.4 | 3.7 | 1.6 | 1.4 | 1.4 | 1.9 | 4.3 | 4.6 |
| 23 | 4.0 | 4.8 | 3.2 | 3.1 | 3.6 | 3.1 | 1.7 | 1.4 | 1.5 | 1.8 | 4.0 | 4.3 |
| 24 | 5.2 | 5.5 | 3.3 | 3.4 | 3.4 | 3.1 | 1.7 | 1.4 | 1.5 | 1.7 | 3.6 | 4.2 |
| 25 | 5.0 | 5.5 | 3.4 | 3.4 | 3.4 | 2.8 | 1.7 | 1.4 | 1.6 | 1.7 | 3.3 | 4.5 |
| 26 | 4.8 | 4.9 | 3.5 | 3.6 | 3.3 | 2.8 | 1.8 | 1.4 | 1.6 | 1.6 | 3.2 | 5.3 |
| 27 | 4.7 | 5.0 | 3.4 | 3.4 | 3.3 | 2.8 | 1.7 | 1.3 | 1.5 | 2.1 | 3.0 | 4.8 |
| 28 | 4.2 | 4.7 | 3.3 | 3.8 | 4.2 | 2.9 | 1.7 | 1.4 | 1.5 | 1.9 | 2.8 | 4.3 |
| 29 | 4.0 | ..... | 3.3 | 3.7 | 5.7 | 2.8 | 1.6 | 1.4 | 1.4 | 1.7 | 2.8 | 4.0 |
| 30 | 3.9 | ..... | 3.3 | 3.6 | 5.1 | 2.7 | 1.6 | 1.4 | 1.4 | 1.7 | 2.6 | 4.0 |
| 31 | 3.8 | ..... | 4.1 | ..... | 4.6 | ..... | 1.6 | 1.4 | ..... | 1.6 | ..... | 4.0 |

NOTE.—From June to August the discharge showed considerable daily fluctuation, caused by storage at logging dams. There was also some backwater from log jams during the same period, especially August 7 to 14.

*Rating table for Middle Fork of Willamette River at Jasper, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.20 | 730 | 2.20 | 1,790 | 3.20 | 3,750 | 4.20 | 6,690 | 5.40 | 11,670 |
| 1.30 | 800 | 2.30 | 1,940 | 3.30 | 3,990 | 4.30 | 7,050 | 5.60 | 12,650 |
| 1.40 | 880 | 2.40 | 2,110 | 3.40 | 4,240 | 4.40 | 7,420 | 5.80 | 13,680 |
| 1.50 | 960 | 2.50 | 2,290 | 3.50 | 4,500 | 4.50 | 7,800 | 6.00 | 14,750 |
| 1.60 | 1,050 | 2.60 | 2,480 | 3.60 | 4,780 | 4.60 | 8,190 | 6.20 | 15,860 |
| 1.70 | 1,150 | 2.70 | 2,670 | 3.70 | 5,070 | 4.70 | 8,590 | 6.40 | 16,990 |
| 1.80 | 1,260 | 2.80 | 2,870 | 3.80 | 5,370 | 4.80 | 9,000 | 6.60 | 18,150 |
| 1.90 | 1,380 | 2.90 | 3,080 | 3.90 | 5,680 | 4.90 | 9,420 | 6.80 | 19,320 |
| 2.00 | 1,510 | 3.00 | 3,300 | 4.00 | 6,000 | 5.00 | 9,850 | 7.00 | 20,500 |
| 2.10 | 1,650 | 3.10 | 3,520 | 4.10 | 6,340 | 5.20 | 10,740 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 6 discharge measurements made during 1905–1907 and is fairly well defined.

*Monthly discharge of Middle Fork of Willamette River at Jasper, Oreg., for 1905–6.*

[Drainage area, 1,450 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| September 16–30 | 1,380 | 730 | 868 | 25,800 | 0.599 | 0.33 |
| October | 3,520 | 880 | 1,580 | 97,200 | 1.09 | 1.26 |
| November | 3,520 | 880 | 1,430 | 85,100 | .986 | 1.10 |
| December | 6,340 | 1,790 | 3,360 | 207,000 | 2.32 | 2.68 |
| The period | 6,340 | 1,790 | ..... | 415,000 | ..... | ..... |
| 1906. | | | | | | |
| January | 16,400 | 3,300 | 6,720 | 413,000 | 4.63 | 5.34 |
| February | 12,200 | 2,870 | 6,290 | 349,000 | 4.34 | 4.52 |
| March | 7,420 | 2,870 | 4,610 | 283,000 | 3 18 | 3.67 |
| April | 8,190 | 3,080 | 4,430 | 264,000 | 3.06 | 3.41 |
| May | 13,200 | 3,080 | 4,760 | 293,000 | 3.28 | 3.78 |
| June | 7,800 | 2,670 | 5,240 | 312,000 | 3.61 | 4.03 |
| July | 2,480 | 1,050 | 1,530 | 94,100 | 1.06 | 1.22 |
| August [a] | 1,150 | 800 | 969 | 59,600 | .668 | .77 |
| September | 2,110 | 880 | 1,040 | 61,900 | .717 | .80 |
| October | 3,080 | 880 | 1,310 | 80,600 | .903 | 1.04 |
| November | 15,300 | 1,050 | 5,710 | 340,000 | 3.94 | 4.40 |
| December | 13,200 | 1,940 | 5,670 | 349,000 | 3.91 | 4.51 |
| The year | 16,400 | 800 | 4,020 | 2,900,000 | 2.77 | 37.49 |

[a] August 7 to 14, discharge estimated at 1,000 second-feet.

NOTE.—Values are rated as follows: September, 1905, to February, 1906, and September to December, 1906, excellent; March, April, July, and August, good; May and June, fair.

## COAST FORK OF WILLAMETTE RIVER NEAR GOSHEN, OREG.

This station was established August 23, 1905. It is located at the highway bridge 3 miles east of Goshen, Oreg., 9 miles southeast of Eugene, and about 4 miles above the junction of Coast and Middle forks of Willamette River. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 221.

*Discharge measurements of Coast Fork of Willamette River near Goshen, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| August 23 | L. R. Allen | 80 | 47 | 0.30 | 67.6 |
| November 7 | do | 165 | 204 | .67 | 182 |
| December 29 | do | 241 | 677 | 2.78 | 1,910 |
| 1906. | | | | | |
| February 2 | L. R. Allen | 242 | 570 | 2.38 | 1,620 |
| March 22 | do | 243 | 697 | 2.87 | 2,260 |
| May 3 | do | 234 | 402 | 1.70 | 917 |
| July 16 | do | 160 | 226 | .82 | 252 |
| August 17 | do | 145 | 158 | .58 | 132 |
| September 19 | I. E. Oakes | 154 | 168 | .65 | 145 |
| 1907. | | | | | |
| January 31 | I. E. Oakes | 256 | 1,870 | 7.75 | 10,700 |

*Daily gage height, in feet, of Coast Fork of Willamette River near Goshen, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.7 | 2.5 | 4.3 | 4.7 | 2.0 | 3.4 | 1.3 | 0.6 | 0.3 | 0.7 | 0.8 | 1.4 |
| 2 | 3.0 | 2.5 | 3.7 | 3.7 | 1.8 | 2.9 | 1.3 | .6 | .3 | .7 | .8 | 1.4 |
| 3 | 2.8 | 2.0 | 3.3 | 3.2 | 1.7 | 2.8 | 1.2 | .6 | .3 | .6 | .8 | 1.5 |
| 4 | 2.8 | 2.0 | 3.2 | 3.0 | 1.5 | 3.0 | 1.2 | .6 | .3 | .5 | 1.0 | 1.5 |
| 5 | 3.1 | 2.0 | 3.0 | 2.7 | 1.5 | 2.7 | 1.3 | .6 | .3 | .7 | 1.5 | 1.7 |
| 6 | 3.0 | 1.8 | 3.0 | 2.6 | 1.5 | 2.6 | 1.1 | .6 | .3 | .7 | 1.6 | 1.8 |
| 7 | 2.7 | 1.8 | 2.9 | 2.5 | 1.5 | 2.7 | 1.1 | .5 | .3 | .5 | 1.9 | 2.3 |
| 8 | 2.5 | 1.7 | 2.9 | 2.2 | 1.4 | 2.9 | 1.1 | .5 | .3 | .5 | 2.0 | 2.9 |
| 9 | 5.0 | 1.6 | 2.8 | 2.3 | 1.4 | 3.5 | 1.1 | .5 | .3 | .5 | 2.5 | 3.0 |
| 10 | 4.0 | 1.6 | 2.7 | 2.2 | 1.4 | 3.0 | 1.0 | .5 | .3 | .6 | 2.0 | 3.4 |
| 11 | 3.6 | 1.6 | 2.5 | 2.0 | 1.4 | 2.7 | 1.0 | .5 | .3 | .6 | 2.0 | 3.0 |
| 12 | 3.5 | 1.5 | 2.3 | 1.9 | 1.3 | 2.5 | 1.0 | .5 | .5 | .8 | 2.0 | 2.7 |
| 13 | 5.4 | 1.3 | 2.1 | 1.7 | 1.3 | 2.5 | 1.0 | .5 | .5 | 1.0 | 2.0 | 2.3 |
| 14 | 4.5 | 1.3 | 2.0 | 1.7 | 1.4 | 2.3 | .9 | .4 | .8 | 1.0 | 3.0 | 2.3 |
| 15 | 4.3 | 1.7 | 1.9 | 1.6 | 2.2 | 2.3 | .9 | .4 | 1.0 | 1.0 | 3.4 | 2.1 |
| 16 | 5.7 | 1.4 | 1.8 | 1.5 | 2.5 | 2.3 | .8 | .4 | 1.0 | 1.2 | 5.2 | 4.0 |
| 17 | 7.5 | 1.6 | 1.6 | 1.5 | 2.2 | 2.9 | .8 | .5 | .8 | 1.5 | 4.3 | 3.7 |
| 18 | 5.4 | 2.0 | 1.7 | 1.5 | 2.0 | 2.6 | .8 | .5 | .8 | 1.9 | 5.0 | 3.0 |
| 19 | 4.5 | 4.5 | 1.7 | 1.4 | 2.0 | 2.3 | .8 | .5 | .7 | 1.8 | 4.7 | 3.2 |
| 20 | 3.7 | 3.7 | 1.9 | 1.4 | 2.0 | 2.0 | .8 | .5 | .5 | 1.7 | 3.0 | 4.4 |
| 21 | 3.3 | 6.2 | 2.7 | 1.4 | 1.9 | 2.0 | .8 | .5 | .5 | 1.5 | 3.6 | 4.0 |
| 22 | 3.0 | 5.6 | 2.9 | 1.5 | 2.4 | 1.8 | .8 | .5 | .5 | 1.4 | 3.0 | 3.0 |
| 23 | 3.5 | 5.2 | 2.6 | 1.6 | 2.9 | 1.5 | .8 | .5 | .6 | 1.4 | 3.0 | 3.0 |
| 24 | 5.4 | 7.0 | 2.5 | 1.6 | 2.5 | 1.6 | .8 | .5 | .7 | 1.0 | 2.6 | 3.4 |
| 25 | 4.4 | 7.0 | 2.4 | 1.7 | 2.3 | 1.6 | .8 | .4 | 1.0 | 1.0 | 2.3 | 4.0 |
| 26 | 3.7 | 5.3 | 2.2 | 2.0 | 2.3 | 1.5 | .7 | .3 | .8 | 1.0 | 2.0 | 5.0 |
| 27 | 3.5 | 6.0 | 2.2 | 1.9 | 2.1 | 1.5 | .7 | .3 | .7 | 1.0 | 2.0 | 4.2 |
| 28 | 3.5 | 5.0 | 2.1 | 2.7 | 2.5 | 1.5 | .7 | .3 | .6 | .9 | 2.0 | 3.3 |
| 29 | 2.7 | ..... | 2.0 | 2.7 | 9.5 | 1.5 | .7 | .3 | .6 | .9 | 1.7 | 2.6 |
| 30 | 2.7 | ..... | 2.0 | 2.2 | 5.7 | 1.4 | .7 | .3 | ..... | .9 | 1.5 | 2.6 |
| 31 | 2.6 | ..... | 3.0 | ..... | 4.4 | ..... | .7 | .3 | ..... | .8 | ..... | 2.3 |

*Rating table for Coast Fork of Willamette River near Goshen, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.20 | 52 | 1.40 | 635 | 2.60 | 1,880 | 3.80 | 3,610 | 6.00 | 7,670 |
| 0.30 | 68 | 1.50 | 720 | 2.70 | 2,005 | 3.90 | 3,775 | 6.20 | 8,070 |
| 0.40 | 89 | 1.60 | 810 | 2.80 | 2,135 | 4.00 | 3,940 | 6.40 | 8,470 |
| 0.50 | 115 | 1.70 | 905 | 2.90 | 2,270 | 4.20 | 4,280 | 6.60 | 8,870 |
| 0.60 | 147 | 1.80 | 1,005 | 3.00 | 2,410 | 4.40 | 4,625 | 6.80 | 9,270 |
| 0.70 | 186 | 1.90 | 1,105 | 3.10 | 2,550 | 4.60 | 4,980 | 7.00 | 9,670 |
| 0.80 | 232 | 2.00 | 1,210 | 3.20 | 2,695 | 4.80 | 5,350 | 8.00 | 11,750 |
| 0.90 | 285 | 2.10 | 1,315 | 3.30 | 2,840 | 5.00 | 5,720 | 9.00 | 13,850 |
| 1.00 | 345 | 2.20 | 1,420 | 3.40 | 2,990 | 5.20 | 6,100 | 10.00 | 16,050 |
| 1.10 | 410 | 2.30 | 1,530 | 3.50 | 3,140 | 5.40 | 6,485 | | |
| 1.20 | 480 | 2.40 | 1,645 | 3.60 | 3,295 | 5.60 | 6,875 | | |
| 1.30 | 555 | 2.50 | 1,760 | 3.70 | 3,450 | 5.80 | 7,270 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 9 discharge measurements made during 1905–1907 and is well defined between gage heights 0.3 foot and 3.0 feet.

*Monthly discharge of Coast Fork of Willamette River near Goshen, Oreg., for 1905–6.*

[Drainage area, 690 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft per sq. mile. | Depth in inches. |
| 1905.[a] | | | | | | |
| August 23–31 | 68 | 58 | 64.7 | 1,150 | 0.094 | 0.031 |
| September 1–20 | 58 | 52 | 56.5 | 2,240 | .082 | .061 |
| October 4–31 | 1,530 | 115 | 492 | 27,300 | .713 | .742 |
| November | 2,410 | 68 | 483 | 28,700 | .701 | .782 |
| December | 5,720 | 555 | 1,870 | 115,000 | 2.71 | 3.12 |
| The period | | | | 174,000 | | |
| 1906.[b] | | | | | | |
| January | 10,700 | 1,760 | 3,820 | 235,000 | 5.54 | 6.39 |
| February | 9,670 | 555 | 3,080 | 171,000 | 4.46 | 4.64 |
| March | 4,450 | 810 | 1,790 | 110,000 | 2.59 | 2.99 |
| April | 5,160 | 635 | 1,460 | 86,900 | 2.12 | 2.36 |
| May | 15,000 | 555 | 1,870 | 115,000 | 2.71 | 3.12 |
| June | 3,140 | 635 | 1,620 | 96,400 | 2.35 | 2.62 |
| July | 555 | 186 | 311 | 19,100 | .451 | .520 |
| August | 147 | 68 | 109 | 6,700 | .158 | .182 |
| September | 345 | 68 | 147 | 8,750 | .213 | .238 |
| October | 1,100 | 115 | 373 | 22,900 | .541 | .62 |
| November | 6,100 | 232 | 1,920 | 114,000 | 2.78 | 3.10 |
| December | 5,720 | 635 | 2,410 | 148,000 | 3.49 | 4.02 |
| The year | 15,000 | 68 | 1,580 | 1,130,000 | 2.28 | 30.80 |

[a] Values for 1905 are rated as follows: August to November, good; December, fair.
[b] Values for 1906 are rated as excellent.

## M'KENZIE RIVER NEAR SPRINGFIELD, OREG.

This station was established September 12, 1905, by L. R. Allen. It is located at Hendricks Ferry, 11 miles above Springfield, about 3 miles above the mouth of Camp Creek. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 222.

*Discharge measurements of McKenzie River near Springfield, Oreg., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| September 12 | L. R. Allen | 395 | 928 | 1.30 | 1,570 |
| November 10 | do | 398 | 880 | 1.12 | 1,810 |
| December 30 | do | 404 | 1,370 | 2.65 | 4,900 |
| 1906. | | | | | |
| February 5 | L. R. Allen | 372 | 1,400 | 2.66 | 5,280 |
| March 24 | do | 342 | 1,190 | 2.14 | 3,690 |
| May 4 | do | 384 | 1,400 | 2.71 | 5,040 |
| June 7 | do | 379 | 1,430 | [a] 2.77 | 5,160 |
| July 26 | do | 327 | 1,100 | [a] 1.40 | 2,250 |
| August 15 | do | 328 | 1,110 | [a] 1.40 | 1,960 |
| September 18 | I. E. Oakes | 315 | 924 | 1.05 | 1,860 |

[a] Affected by log jam.

*Daily gage height, in feet, of McKenzie River near Springfield, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.4 | 3.1 | 3.3 | 3.55 | 2.75 | 2.85 | 1.9 | 1.4 | 1.4 | 1.0 | 1.3 | 2.1 |
| 2 | 2.2 | 3.0 | 3.1 | 2.85 | 2.65 | 2.75 | 1.85 | 1.4 | 1.4 | 1.15 | 1.3 | 2.0 |
| 3 | 2.1 | 2.9 | 3.0 | 2.7 | 2.65 | 2.7 | 1.8 | 1.4 | 1.4 | 1.15 | 1.3 | 1.9 |
| 4 | 2.2 | 2.75 | 2.85 | 2.65 | 2.7 | 2.7 | 1.8 | 1.4 | 1.4 | 1.1 | 1.4 | 1.95 |
| 5 | 2.3 | 2.55 | 2.8 | 2.5 | 2.6 | 2.8 | 1.75 | 1.4 | 1.4 | 1.1 | 1.5 | 2.0 |
| 6 | 2.45 | 2.5 | 2.9 | 2.75 | 2.6 | 3.0 | 1.75 | 1.4 | 1.4 | 1.1 | 1.55 | 2.05 |
| 7 | 2.5 | 2.4 | 3.0 | 2.8 | 2.5 | 3.25 | 1.7 | 1.4 | 1.4 | 1.05 | 1.35 | 3.1 |
| 8 | 2.5 | 2.3 | 3.3 | 2.9 | 2.5 | 3.15 | 1.7 | 1.4 | 1.4 | 1.05 | 4.6 | 2.95 |
| 9 | 3.2 | 2.2 | 3.2 | 3.0 | 2.5 | 3.4 | 1.65 | 1.4 | 1.4 | 1.0 | 3.2 | 2.75 |
| 10 | 2.8 | 2.1 | 3.15 | 2.85 | 2.5 | 3.2 | 1.7 | 1.4 | 1.4 | 1.0 | 3.7 | 2.7 |
| 11 | 3.0 | 2.1 | 2.85 | 2.7 | 2.45 | 3.05 | 1.8 | 1.4 | 1.4 | 1.0 | 4.4 | 2.6 |
| 12 | 3.1 | 2.05 | 2.7 | 2.6 | 2.35 | 2.8 | 1.85 | 1.4 | 1.6 | 1.3 | 3.0 | 3.1 |
| 13 | 3.3 | 2.0 | 2.6 | 2.55 | 2.25 | 2.7 | 1.95 | 1.4 | 1.8 | 1.15 | 5.6 | 3.2 |
| 14 | 3.05 | 2.0 | 2.4 | 2.55 | 2.7 | 3.1 | 2.05 | 1.45 | 2.15 | 1.25 | 6.5 | 3.2 |
| 15 | 2.85 | 2.1 | 2.3 | 2.7 | 2.6 | 3.45 | 2.0 | 1.4 | 2.25 | 1.3 | 6.5 | 2.95 |
| 16 | 4.25 | 2.15 | 2.2 | 2.75 | 2.55 | 3.4 | 2.05 | 1.4 | 1.8 | 1.95 | 6.2 | 2.9 |
| 17 | 3.7 | 2.4 | 2.15 | 2.8 | 2.45 | 3.1 | 1.5 | 1.4 | 1.2 | 2.6 | 5.35 | 2.9 |
| 18 | 3.5 | 3.0 | 2.1 | 2.75 | 2.4 | 2.95 | 1.4 | 1.4 | 1.1 | 2.3 | 4.3 | 2.8 |
| 19 | 3.2 | 3.95 | 2.0 | 2.7 | 2.35 | 2.8 | 1.4 | 1.4 | 1.05 | 2.2 | 4.1 | 2.75 |
| 20 | 2.95 | 4.6 | 2.0 | 2.35 | 2.35 | 2.45 | 1.45 | 1.4 | 1.25 | 1.9 | 4.0 | 4.0 |
| 21 | 2.5 | 4.2 | 2.1 | 2.5 | 2.55 | 2.3 | 1.45 | 1.4 | 1.2 | 1.6 | 3.9 | 6.0 |
| 22 | 2.95 | 4.05 | 2.1 | 2.55 | 2.6 | 2.2 | 1.5 | 1.4 | 1.15 | 1.45 | 3.6 | 4.9 |
| 23 | 4.9 | 4.1 | 2.0 | 2.85 | 2.55 | 2.15 | 1.45 | 1.4 | 1.1 | 1.4 | 3.3 | 4.85 |
| 24 | 4.45 | 4.3 | 2.15 | 3.0 | 2.5 | 2.1 | 1.45 | 1.4 | 1.1 | 1.4 | 3.2 | 4.65 |
| 25 | 4.2 | 4.05 | 2.24 | 3.15 | 2.5 | 2.05 | 1.45 | 1.4 | 1.1 | 1.35 | 2.9 | 4.4 |
| 26 | 3.6 | 3.9 | 2.5 | 2.9 | 2.55 | 2.0 | 1.45 | 1.4 | 1.05 | 1.7 | 2.6 | 4.15 |
| 27 | 3.35 | 3.6 | 2.55 | 2.85 | 2.45 | 2.0 | 1.45 | 1.4 | 1.05 | 2.0 | 2.55 | 3.9 |
| 28 | 3.2 | 3.45 | 2.5 | 2.9 | 3.7 | 2.05 | 1.4 | 1.4 | 1.05 | 1.7 | 2.45 | 3.65 |
| 29 | 3.0 | ..... | 2.5 | 2.8 | 3.65 | 2.0 | 1.4 | 1.4 | 1.0 | 1.8 | 2.3 | 3.45 |
| 30 | 3.15 | ..... | 2.8 | 2.75 | 3.45 | 1.95 | 1.4 | 1.4 | 1.0 | 1.6 | 2.2 | 3.2 |
| 31 | 3.3 | ..... | 3.5 | ..... | 3.0 | ..... | 1.4 | 1.4 | ..... | 1.8 | ..... | 2.95 |

*Rating table for McKenzie River near Springfield, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.00 | 1,630 | 1.80 | 3,000 | 2.60 | 4,760 | 3.40 | 6,920 | 4.40 | 10,090 |
| 1.10 | 1,780 | 1.90 | 3,200 | 2.70 | 5,010 | 5.50 | 7,210 | 4.60 | 10,770 |
| 1.20 | 1,930 | 2.00 | 3,410 | 2.80 | 5,270 | 3.60 | 7,510 | 4.80 | 11,450 |
| 1.30 | 2,090 | 2.10 | 3,620 | 2.90 | 5,530 | 3.70 | 7,820 | 5.00 | 12,150 |
| 1.40 | 2,260 | 2.20 | 3,840 | 3.00 | 5,800 | 3.80 | 8,130 | 6.00 | 15,650 |
| 1.50 | 2,440 | 2.30 | 4,060 | 3.10 | 6,070 | 3.90 | 8,450 | 7.00 | 19,250 |
| 1.60 | 2,620 | 2.40 | 4,290 | 3.20 | 6,350 | 4.00 | 8,770 | | |
| 1.70 | 2,810 | 2.50 | 4,520 | 3.30 | 6,630 | 4.20 | 9,420 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 6 discharge measurements made during 1905–6 and is fairly well defined between gage heights 1 foot and 3 feet.

*Monthly discharge of McKenzie River near Springfield, Oreg., for 1905–6.*

[Drainage area, 960 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905.[a] | | | | | | |
| September 12–30 | 2,810 | 2,090 | 2,230 | 84,000 | 2.32 | 1.64 |
| October | 5,270 | 2,090 | 2,770 | 170,000 | 2.89 | 3.33 |
| November | 4,060 | 1,780 | 2,260 | 134,000 | 2.35 | 2.62 |
| December | 6,920 | 2,810 | 4,010 | 247,000 | 4.18 | 4.82 |
| The period | | | | 635,000 | | |
| 1906.[b] | | | | | | |
| January | 11,800 | 3,620 | 6,200 | 381,000 | 6.46 | 7.45 |
| February | 10,800 | 3,410 | 5,980 | 332,000 | 6.23 | 6.49 |
| March | 7,210 | 3,410 | 4,850 | 298,000 | 5.05 | 5.82 |
| April | 7,360 | 4,170 | 5,220 | 311,000 | 5.44 | 6.07 |
| May | 7,820 | 3,950 | 4,900 | 301,000 | 5.10 | 5.88 |
| June | 7,060 | 3,300 | 5,040 | 300,000 | 5.25 | 5.86 |
| July | 3,510 | 2,260 | 2,710 | 167,000 | 2.82 | 3.25 |
| August | 2,350 | 2,260 | 2,260 | 139,000 | 2.35 | 2.71 |
| September[c] | 3,950 | 1,630 | 2,200 | 131,000 | 2.29 | 2.56 |
| October | 4,760 | 1,630 | 2,440 | 150,000 | 2.54 | 2.93 |
| November | 17,400 | 2,090 | 7,300 | 434,000 | 7.60 | 8.48 |
| December | 15,600 | 3,200 | 6,650 | 409,000 | 6.93 | 7.99 |
| The period | 17,400 | 1,630 | 4,650 | 3,350,000 | 4.84 | 65.49 |

[a] Values for 1905 are rated as follows: November and December, excellent; October, fair; September, approximate.

[b] Values are rated as follows: January to July, good; August to December, fair.

[c] During the morning of September 17, 1906, there was a drop of 0.5 foot in the water due to the removal of a log jam lodged on a bar 200 yards below the gage. The daily discharge September 12 to 17 was applied as if open-channel conditions existed. It is impossible to judge accurately the extent of the backwater effect from this log jam owing to a natural rise from rains about the middle of September, but the monthly mean for this month is believed to be not more than 2 or 3 per cent too high from this cause. Estimates for this station are affected by log drives which cause changes in the channel and modify the flow generally.

## NORTH FORK OF SANTIAM RIVER AT MEHAMA, OREG.

This station was established July 11, 1905. It is located just below the highway bridge at Mehama, Oreg., about 1½ miles north of Lyons, the nearest railroad station, which is about 12 miles below the junction of Little North Fork and North Fork. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 224.

*Discharge measurements of North Fork of Santiam River at Mehama, Oreg., in 1905–1907.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| July 11 | L. R. Allen | 160 | 756 | 2.90 | 1,050 |
| October 18[a] | do | 202 | 1,010 | 4.44 | 3,560 |
| November 16 | J. H. Lewis | 155 | 756 | 2.90 | 973 |
| December 12 | L. R. Allen | 250 | 927 | 4.24 | 2,880 |
| 1906. | | | | | |
| January 4[a] | L. R. Allen | 249 | 926 | 4.20 | 2,230 |
| February 7 | do | 251 | 1,000 | 4.51 | 3,320 |
| March 26 | do | 250 | 927 | 4.20 | 2,740 |
| May 7 | do | 250 | 947 | 4.28 | 2,800 |
| May 15[b] | do | 253 | 1,030 | 4.65 | 3,060 |
| July 17 | do | 242 | 632 | 3.04 | 1,080 |
| August 21 | do | 237 | 550 | 2.64 | 756 |
| September 27 | I. E. Oakes | 242 | 585 | 2.83 | 905 |
| 1907. | | | | | |
| February 6 | I. E. Oakes | 305 | 2,710 | 11.00 | 29,100 |

[a] Measurement unreliable. [b] Backwater from log jam.

*Daily gage height, in feet, of North Fork of Santiam River at Mehama, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.35 | 5.8 | 5.5 | 5.45 | 5.0 | 4.3 | 3.8 | 2.8 | 2.6 | 2.7 | 3.3 | 3.75 |
| 2 | 4.2 | 5.9 | 5.3 | 5.0 | 4.6 | 4.1 | 3.8 | 2.8 | 2.55 | 2.8 | 3.25 | 3.7 |
| 3 | 4.1 | 5.5 | 5.2 | 4.7 | 4.6 | 4.2 | 3.7 | 2.8 | 2.55 | 3.55 | 3.2 | 3.7 |
| 4 | 4.2 | 5.2 | 5.15 | 4.55 | 4.6 | 4.8 | 3.65 | 2.75 | 2.55 | 3.6 | 3.45 | 3.5 |
| 5 | 4.4 | 5.0 | 5.0 | 4.55 | 4.6 | 4.5 | 3.6 | 2.75 | 2.55 | 3.3 | 3.8 | 3.75 |
| 6 | 4.5 | 4.75 | 5.25 | 4.8 | 4.3 | 5.0 | 3.5 | 2.75 | 2.55 | 3.1 | 3.7 | 4.0 |
| 7 | 4.5 | 4.6 | 5.4 | 5.0 | 4.3 | 5.4 | 3.4 | 2.75 | 2.55 | 2.95 | 9.65 | 6.2 |
| 8 | 4.6 | 4.4 | 5.6 | 5.0 | 4.3 | 5.1 | 3.35 | 2.75 | 2.55 | 2.9 | 10.0 | 5.5 |
| 9 | 5.1 | 4.25 | 5.5 | 5.3 | 4.5 | 5.1 | 3.3 | 2.75 | 2.65 | 2.8 | 6.9 | 5.2 |
| 10 | 4.85 | 4.15 | 5.65 | 5.0 | 4.6 | 5.1 | 3.25 | 2.7 | 2.65 | 2.8 | 8.5 | 4.8 |
| 11 | 5.5 | 4.05 | 5.2 | 5.0 | 5.0 | 4.7 | 3.25 | 2.7 | 2.6 | 2.8 | 6.5 | 4.85 |
| 12 | 5.0 | 4.0 | 4.9 | 5.0 | 4.45 | 4.8 | 3.2 | 2.7 | 2.7 | 3.25 | 6.75 | 4.6 |
| 13 | 5.3 | 3.9 | 4.7 | 4.85 | 4.25 | 4.7 | 3.2 | 2.7 | 3.15 | 3.3 | 11.25 | 4.5 |
| 14 | 5.0 | 3.9 | 4.4 | 4.8 | 4.4 | 4.4 | 3.2 | 2.7 | 4.1 | 3.0 | 12.35 | 4.2 |
| 15 | 4.7 | 4.2 | 4.2 | 4.5 | 5.0 | 4.5 | 3.15 | 2.7 | 4.2 | 3.3 | 11.7 | 4.5 |
| 16 | 5.3 | 4.3 | 4.1 | 4.6 | 4.2 | 5.4 | 3.1 | 2.7 | 3.1 | 5.1 | 8.8 | 7.3 |
| 17 | 5.3 | 4.9 | 3.9 | 4.6 | 4.05 | 5.0 | 3.1 | 2.7 | 3.05 | 5.3 | 9.1 | 5.4 |
| 18 | 5.15 | 6.2 | 3.95 | 4.3 | 4.05 | 4.75 | 3.0 | 2.7 | 2.9 | 5.2 | 8.65 | 5.0 |
| 19 | 4.8 | 7.7 | 3.9 | 4.3 | 4.25 | 4.5 | 3.0 | 2.65 | 2.9 | 4.75 | 6.6 | 5.4 |
| 20 | 4.5 | 8.1 | 3.8 | 4.3 | 4.2 | 4.35 | 3.0 | 2.65 | 2.8 | 4.35 | 5.9 | 10.6 |
| 21 | 4.35 | 7.85 | 3.8 | 4.9 | 4.5 | 4.2 | 2.95 | 2.65 | 2.75 | 3.9 | 6.05 | 9.6 |
| 22 | 4.5 | 7.05 | 3.8 | 4.7 | 4.5 | 4.2 | 2.95 | 2.65 | 2.7 | 3.7 | 5.5 | 7.2 |
| 23 | 6.3 | 6.85 | 3.7 | 4.6 | 4.5 | 3.9 | 2.95 | 2.6 | 2.7 | 3.5 | 5.1 | 6.4 |
| 24 | 8.55 | 6.4 | 3.95 | 4.5 | 4.3 | 3.9 | 2.9 | 2.6 | 2.95 | 3.4 | 4.9 | 6.4 |
| 25 | 6.8 | 6.05 | 3.05 | 5.2 | 4.2 | 3.8 | 2.9 | 2.6 | 3.15 | 3.4 | 4.6 | 6.6 |
| 26 | 6.25 | 6.4 | 4.2 | 5.2 | 4.3 | 3.75 | 2.85 | 2.6 | 2.9 | 4.2 | 4.4 | 6.6 |
| 27 | 5.85 | 6.6 | 4.3 | 4.95 | 4.2 | 3.65 | 2.85 | 2.6 | 2.8 | 4.3 | 4.3 | 6.3 |
| 28 | 5.5 | 5.95 | 4.25 | 5.2 | 4.1 | 3.65 | 2.85 | 2.6 | 2.8 | 3.85 | 4.0 | 5.45 |
| 29 | 5.4 | ..... | 4.25 | 4.95 | 4.35 | 3.65 | 2.8 | 2.6 | 2.75 | 3.8 | 4.0 | 5.2 |
| 30 | 5.4 | ..... | 4.65 | 4.9 | 4.6 | 3.85 | 2.8 | 2.6 | ..... | 3.5 | 3.8 | 5.2 |
| 31 | 6.1 | ..... | 6.1 | ..... | 4.35 | ..... | 2.8 | 2.6 | ..... | 3.4 | ..... | 5.0 |

NOTE.—Gage heights for May and June were affected by log jams.

*Rating table for North Fork of Santiam River at Mehama, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.40 | 590 | 3.40 | 1,570 | 4.40 | 3,100 | 5.80 | 6,410 | 7.80 | 13,750 |
| 2.50 | 660 | 3.50 | 1,700 | 4.50 | 3,280 | 6.00 | 7,000 | 8.00 | 14,600 |
| 2.60 | 740 | 3.60 | 1,840 | 4.60 | 3,470 | 6.20 | 7,630 | 9.00 | 19,200 |
| 2.70 | 820 | 3.70 | 1,980 | 4.70 | 3,670 | 6.40 | 8,300 | 10.00 | 24,100 |
| 2.80 | 910 | 3.80 | 2,130 | 4.80 | 3,880 | 6.60 | 9,000 | 11.00 | 29,100 |
| 2.90 | 1,000 | 3.90 | 2,280 | 4.90 | 4,100 | 6.80 | 9,730 | 12.00 | 34,300 |
| 3.00 | 1,100 | 4.00 | 2,430 | 5.00 | 4,330 | 7.00 | 10,500 | 13.00 | 39,800 |
| 3.10 | 1,210 | 4.10 | 2,590 | 5.20 | 4,810 | 7.20 | 11,290 | | |
| 3.20 | 1,320 | 4.20 | 2,750 | 5.40 | 5,320 | 7.40 | 12,090 | | |
| 3.30 | 1,440 | 4.30 | 2,920 | 5.60 | 5,850 | 7.60 | 12,910 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 10 discharge measurements made during 1905–1907 and is well defined between gage heights 2.5 feet and 4.5 feet.

*Monthly discharge of North Fork of Santiam River at Mehama, Oreg., for 1905–6.*

[Drainage area, 740 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| July 11–31 | 1,000 | 780 | 876 | 36,500 | 1.18 | 0.92 |
| August | 780 | 660 | 727 | 44,700 | .982 | 1.13 |
| September | 3,010 | 625 | 952 | 56,600 | 1.29 | 1.44 |
| October | 9,730 | 1,500 | 3,460 | 213,000 | 4.68 | 5.40 |
| November | 3,880 | 1,000 | 1,830 | 109,000 | 2.47 | 2.76 |
| December | 6,700 | 2,430 | 4,010 | 247,000 | 5.42 | 6.25 |
| The period | | | | 707,000 | | |
| 1906. | | | | | | |
| January | 17,100 | 2,590 | 5,050 | 311,000 | 6.82 | 7.86 |
| February | 15,000 | 2,280 | 6,180 | 343,000 | 8.35 | 8.70 |
| March | 7,310 | 1,150 | 3,680 | 226,000 | 4.97 | 5.73 |
| April | 5,450 | 2,920 | 3,970 | 236,000 | 5.36 | 5.98 |
| May | 4,330 | 2,510 | 3,170 | 195,000 | 4.28 | 4.93 |
| June | 5,320 | 1,910 | 3,280 | 195,000 | 4.43 | 4.94 |
| July | 2,130 | 910 | 1,310 | 80,600 | 1.77 | 2.04 |
| August | 910 | 740 | 809 | 49,700 | 1.09 | 1.26 |
| September | 2,750 | 700 | 1,030 | 61,300 | 1.39 | 1.55 |
| October | 5,060 | 820 | 1,990 | 122,000 | 2.69 | 3.10 |
| November | 36,200 | 1,320 | 10,300 | 613,000 | 13.92 | 15.53 |
| December | 27,100 | 1,700 | 6,450 | 397,000 | 8.72 | 10.05 |
| The year | 36,200 | 700 | 3,930 | 2,830,000 | 5.31 | 71.67 |

NOTE.—Values are rated as follows: 1905, January, April, and July to December, 1906, excellent; May and June, 1906, fair; affected by log jams.

## SOUTH FORK OF SANTIAM RIVER AT WATERLOO, OREG.

This station was established July 28, 1905. It is located about one-half mile below the highway bridge at Waterloo, Oreg. The station is about 4 miles above the mouth of Hamilton Creek, and about 3 miles above a dam which diverts water into a canal for the use of the town of Albany. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 225.

*Discharge measurements of South Fork of Santiam River at Waterloo, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| July 28 | L. R. Allen | 150 | 246 | 1.06 | 375 |
| 1906. | | | | | |
| January 5 | L. R. Allen | 315 | 831 | 3.49 | 3,550 |
| February 6 | do | 315 | 802 | 3.36 | 3,410 |
| March 27 | do | 304 | 616 | 2.85 | 2,390 |
| May 8 | do | 238 | 460 | 2.30 | 1,560 |
| May 14 | do | 243 | 481 | 2.28 | 1,550 |
| August 20 | do | 142 | 199 | .93 | 263 |
| September 26 | I. E. Oakes | 155 | 273 | 1.40 | 555 |

*Daily gage height, in feet, of South Fork of Santiam River at Waterloo, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.7 | 4.6 | 4.6 | 4.4 | 3.1 | 3.2 | 2.2 | 1.2 | 0.7 | 1.2 | 2.9 | 2.5 |
| 2 | 3.2 | 4.4 | 4.2 | 3.7 | 2.4 | 3.0 | 2.1 | 1.2 | .7 | 1.1 | 2.9 | 2.5 |
| 3 | 3.3 | 4.3 | 3.9 | 3.5 | 2.7 | 2.9 | 2.0 | 1.2 | .7 | 1.5 | 2.9 | 2.4 |
| 4 | 3.2 | 3.9 | 3.9 | 3.3 | 2.7 | 3.5 | 1.8 | 1.1 | .7 | 2.0 | 2.5 | 2.4 |
| 5 | 3.4 | 3.6 | 3.9 | 3.2 | 2.5 | 3.2 | 1.7 | 1.1 | .7 | 1.6 | 2.3 | 2.5 |
| 6 | 3.5 | 3.4 | 4.0 | 3.1 | 2.4 | 3.6 | 1.8 | 1.1 | .7 | 1.5 | 2.3 | 2.6 |
| 7 | 3.7 | 3.1 | 4.6 | 3.2 | 2.4 | 3.8 | 1.8 | 1.1 | .7 | 1.3 | 7.4 | 3.5 |
| 8 | 3.6 | 3.1 | 4.4 | 3.1 | 2.3 | 4.3 | 1.7 | 1.1 | .7 | 1.2 | 11.2 | 4.0 |
| 9 | 4.2 | 3.0 | 4.5 | 3.5 | 2.3 | 4.0 | 1.7 | 1.0 | .7 | 1.1 | 6.6 | 3.7 |
| 10 | 4.0 | 2.9 | 4.2 | 3.2 | 2.3 | 3.4 | 1.6 | 1.0 | .7 | 1.1 | 5.3 | 3.6 |
| 11 | 4.1 | 2.7 | 3.8 | 3.0 | 2.2 | 3.9 | 1.6 | 1.0 | .7 | 1.0 | 5.6 | 3.6 |
| 12 | 4.3 | 2.6 | 3.5 | 2.8 | 2.2 | 3.3 | 1.6 | 1.0 | .7 | 1.3 | 7.5 | 3.5 |
| 13 | 5.0 | 2.6 | 3.3 | 2.7 | 2.1 | 3.3 | 1.6 | 1.0 | .7 | 1.5 | 10.0 | 3.7 |
| 14 | 4.4 | 2.6 | 3.2 | 2.6 | 2.3 | 3.1 | 1.5 | 1.0 | 1.8 | 1.3 | 13.5 | 3.3 |
| 15 | 4.3 | 3.0 | 2.9 | 2.6 | 2.6 | 3.1 | 1.5 | 1.0 | 1.9 | 1.4 | 10.0 | 4.1 |
| 16 | 4.6 | 3.0 | 2.7 | 2.7 | 2.8 | 3.7 | 1.5 | 1.0 | 1.7 | 1.5 | 8.5 | 4.0 |
| 17 | 5.4 | 3.4 | 2.7 | 2.6 | 2.6 | 3.7 | 1.5 | 1.0 | 1.7 | 4.4 | 8.5 | 3.6 |
| 18 | 5.0 | 3.8 | 2.6 | 2.5 | 2.6 | 3.2 | 1.5 | 1.0 | 1.7 | 4.0 | 8.2 | 4.5 |
| 19 | 4.4 | 5.9 | 2.6 | 2.5 | 2.8 | 3.0 | 1.4 | 1.0 | 1.4 | 4.7 | 8.1 | 7.7 |
| 20 | 3.9 | 7.0 | 2.5 | 2.5 | 2.7 | 2.7 | 1.4 | .9 | 1.3 | 4.8 | 5.2 | 7.8 |
| 21 | 3.5 | 6.9 | 2.6 | 2.7 | 3.2 | 2.7 | 1.3 | .8 | 1.2 | 2.3 | 5.1 | 6.5 |
| 22 | 3.4 | 5.9 | 2.6 | 2.6 | 3.4 | 2.6 | 1.3 | .8 | 1.2 | 2.3 | 4.8 | 5.0 |
| 23 | 4.8 | 5.9 | 2.5 | 2.6 | 3.2 | 2.5 | 1.3 | .8 | 1.2 | 2.1 | 4.2 | 4.85 |
| 24 | 7.1 | 5.9 | 2.6 | 2.6 | 3.0 | 2.4 | 1.3 | .8 | 1.3 | 2.1 | 4.8 | 4.8 |
| 25 | 6.1 | 5.6 | 2.6 | 2.8 | 2.9 | 2.2 | 1.3 | .8 | 1.3 | 2.3 | 3.5 | 5.6 |
| 26 | 5.5 | 5.3 | 2.8 | 3.8 | 2.4 | 2.2 | 1.2 | .7 | 1.3 | 2.4 | 3.3 | 5.9 |
| 27 | 4.9 | 6.2 | 2.9 | 3.5 | 3.0 | 2.3 | 1.2 | .7 | 1.0 | 2.9 | 3.4 | 4.8 |
| 28 | 4.5 | 5.1 | 2.8 | 3.7 | 2.9 | 2.3 | 1.2 | .7 | 1.0 | 2.5 | 3.0 | 4.4 |
| 29 | 4.3 | ..... | 2.9 | 3.5 | 3.7 | 2.4 | 1.2 | .7 | 1.1 | 2.2 | 2.7 | 4.0 |
| 30 | 4.5 | ..... | 2.8 | 3.2 | 3.8 | 2.4 | 1.2 | .7 | 1.1 | 2.1 | 2.7 | 3.1 |
| 31 | 4.8 | ..... | 4.5 | ..... | 3.6 | ..... | 1.2 | .7 | ..... | 2.3 | ..... | 3.8 |

*Rating table for South Fork of Santiam River at Waterloo, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.50 | 128 | 1.70 | 850 | 2.90 | 2,510 | 4.20 | 5,260 | 6.60 | 12,380 |
| 0.60 | 158 | 1.80 | 960 | 3.00 | 2,680 | 4.40 | 5,780 | 6.80 | 13,040 |
| 0.70 | 192 | 1.90 | 1,070 | 3.10 | 2,860 | 4.60 | 6,310 | 7.00 | 13,700 |
| 0.80 | 230 | 2.00 | 1,190 | 3.20 | 3,050 | 4.80 | 6,850 | 8.00 | 17,000 |
| 0.90 | 273 | 2.10 | 1,320 | 3.30 | 3,240 | 5.00 | 7,400 | 9.00 | 20,400 |
| 1.00 | 320 | 2.20 | 1,450 | 3.40 | 3,440 | 5.20 | 7,980 | 10.00 | 23,900 |
| 1.10 | 370 | 2.30 | 1,590 | 3.50 | 3,640 | 5.40 | 8,580 | 11.00 | 27,500 |
| 1.20 | 430 | 2.40 | 1,730 | 3.60 | 3,850 | 5.60 | 9,190 | 12.00 | 31,200 |
| 1.30 | 500 | 2.50 | 1,870 | 3.70 | 4,070 | 5.80 | 9,810 | 13.00 | 35,000 |
| 1.40 | 580 | 2.60 | 2,020 | 3.80 | 4,290 | 6.00 | 10,450 | 14.00 | 38,800 |
| 1.50 | 660 | 2.70 | 2,180 | 3.90 | 4,520 | 6.20 | 11,090 | | |
| 1.60 | 750 | 2.80 | 2,340 | 4.00 | 4,760 | 6.40 | 11,730 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 8 discharge measurements made during 1905–6 and is well defined between gage heights 0.9 foot and 4 feet.

*Monthly discharge of South Fork of Santiam River at Waterloo, Oreg., for 1905–6.*

[Drainage area, 640 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905.[a] | | | | | | |
| August | 345 | 230 | 297 | 18,300 | .464 | 0.54 |
| September | 1,070 | 158 | 314 | 18,700 | .491 | .55 |
| October | 6,040 | 660 | 2,340 | 144,000 | 3.66 | 4.22 |
| November | 3,440 | 580 | 1,270 | 75,600 | 1.98 | 2.21 |
| December | 7,120 | 2,180 | 4,140 | 255,000 | 6.47 | 7.46 |
| The period | | | | 512,000 | | |
| 1906.[b] | | | | | | |
| January | 14,000 | 3,050 | 5,790 | 356,000 | 9.05 | 10.43 |
| February | 13,700 | 2,020 | 5,910 | 328,000 | 9.23 | 9.61 |
| March | 6,310 | 1,870 | 3,490 | 215,000 | 5.45 | 6.28 |
| April | 5,780 | 1,870 | 2,850 | 170,000 | 4.45 | 4.96 |
| May | 4,290 | 1,320 | 2,310 | 142,000 | 3.61 | 4.16 |
| June | 5,520 | 1,450 | 2,900 | 173,000 | 4.53 | 5.05 |
| July | 1,450 | 430 | 707 | 43,500 | 1.10 | 1.27 |
| August | 430 | 192 | 298 | 18,300 | .466 | .54 |
| September | 1,070 | 192 | 411 | 24,500 | .642 | .72 |
| October | 6,850 | 320 | 1,640 | 101,000 | 2.56 | 2.95 |
| November | 36,900 | 1,590 | 10,300 | 613,000 | 16.09 | 17.95 |
| December | 16,300 | 1,730 | 5,470 | 336,000 | 8.55 | 9.86 |
| The period | 36,900 | 192 | 3,510 | 2,520,000 | 5.48 | 73.78 |

[a] Values for 1905 are rated as follows: October to December, excellent; August and September, good.
[b] Values for 1906 are rated as follows: March to July, September, and October, excellent; remainder of the year, good.

## LUCKIAMUTE RIVER NEAR SUVER, OREG.

This station was established August 18, 1905. It is located just below Helmick bridge on the public highway, 4 miles northwest of Suver, Oreg., 2 miles west of Parkers Station, and about 3 miles below the junction of the main forks of the river. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 226.

*Discharge measurements of Luckiamute River near Suver, Oreg., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| August 18 | L. R. Allen | 45 | 121 | 1.47 | 73 |
| October 7 | do | 79 | 571 | 8.57 | 1,180 |
| 1906. | | | | | |
| January 10 | P. A. Cupper | 78 | 508 | 7.60 | 928 |
| April 5 | L. R. Allen | 62 | 322 | 5.01 | 495 |
| May 16 | do | 62 | 356 | 5.59 | 592 |
| June 30 | do | 61 | 290 | 4.28 | 396 |

*Daily gage height, in feet, of Luckiamute River near Suver, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.6 | 8.35 | 15.8 | 6.8 | 3.95 | 4.0 | 3.8 | 2.0 | 1.25 | 1.5 | 3.5 | 6.9 |
| 2 | 12.3 | 7.5 | 13.6 | 5.9 | 3.85 | 3.6 | 3.75 | 1.85 | .85 | 1.55 | 2.6 | 6.1 |
| 3 | 11.25 | 7.3 | 12.05 | 5.3 | 3.65 | 4.0 | 3.5 | 1.8 | .95 | 2.45 | 3.0 | 7.3 |
| 4 | 9.5 | 7.4 | 10.8 | 5.1 | 4.35 | 4.4 | 3.5 | 1.2 | 1.25 | 2.85 | 4.0 | 5.9 |
| 5 | 7.75 | 6.5 | 9.95 | 5.0 | 4.6 | 4.8 | 3.25 | 1.85 | 1.2 | 1.95 | 8.2 | 5.5 |
| 6 | 8.2 | 6.2 | 9.3 | 5.1 | 5.25 | 4.25 | 3.1 | 1.85 | 1.2 | 1.6 | 7.1 | 5.7 |
| 7 | 8.5 | 5.7 | 8.55 | 4.9 | 5.0 | 4.9 | 3.05 | 1.75 | 1.2 | 1.45 | 10.9 | 13.0 |
| 8 | 7.8 | 5.45 | 8.1 | 4.8 | 3.1 | 5.1 | 3.05 | 1.85 | 1.15 | 1.8 | 23.1 | 12.5 |
| 9 | 9.0 | 5.3 | 7.6 | 5.0 | 3.2 | 4.8 | 2.9 | 1.8 | .95 | 1.9 | 23.6 | 11.1 |
| 10 | 8.3 | 5.2 | 7.4 | 5.8 | 3.05 | 4.35 | 2.85 | 2.15 | 1.25 | 1.7 | 17.6 | 12.8 |
| 11 | 9.0 | 5.1 | 7.2 | 5.25 | 3.0 | 4.2 | 2.8 | 1.8 | 1.2 | 1.7 | 18.8 | 12.9 |
| 12 | 10.8 | 4.9 | 6.75 | 4.35 | 2.9 | 5.1 | 2.7 | 1.75 | 1.35 | 2.5 | 13.0 | 10.9 |
| 13 | 17.15 | 4.6 | 6.35 | 4.75 | 3.0 | 5.4 | 2.65 | 1.7 | 2.5 | 3.9 | 15.4 | 10.8 |
| 14 | 17.15 | 4.5 | 6.1 | 4.3 | 3.2 | 5.6 | 2.6 | 1.75 | 2.3 | 3.2 | 18.7 | 10.3 |
| 15 | 16.15 | 4.7 | 6.85 | 3.9 | 3.9 | 5.3 | 2.65 | 1.7 | 2.55 | 3.3 | 22.1 | 12.6 |
| 16 | 17.6 | 4.9 | 5.4 | 3.83 | 5.6 | 8.7 | 2.25 | 1.75 | 2.5 | 7.5 | 25.9 | 13.0 |
| 17 | 20.8 | 6.4 | 5.4 | 3.85 | 6.7 | 7.5 | 2.3 | 1.65 | 1.9 | 8.35 | 23.1 | 12.2 |
| 18 | 21.6 | 12.3 | 5.3 | 3.75 | 4.2 | 7.2 | 2.5 | 1.6 | 1.75 | 6.5 | 18.9 | 11.5 |
| 19 | 18.6 | 18.5 | 5.7 | 3.8 | 4.1 | 6.0 | 2.35 | 1.65 | 1.65 | 5.6 | 15.4 | 13.1 |
| 20 | 16.55 | 15.5 | 5.95 | 3.8 | 4.25 | 5.6 | 2.5 | 1.45 | 1.55 | 4.8 | 13.0 | 18.0 |
| 21 | 15.5 | 23.2 | 6.5 | 3.7 | 4.3 | 5.1 | 2.3 | 1.5 | 1.45 | 3.45 | 12.8 | 22.0 |
| 22 | 13.2 | 22.0 | 6.6 | 3.6 | 4.4 | 4.6 | 2.2 | 1.55 | 1.3 | 3.6 | 12.6 | 24.5 |
| 23 | 16.6 | 21.5 | 7.1 | 3.5 | 3.4 | 4.3 | 2.15 | 1.5 | 1.5 | 3.4 | 11.0 | 18.0 |
| 24 | 21.6 | 22.5 | 7.3 | 3.5 | 3.8 | 4.25 | 2.15 | 1.4 | 1.65 | 3.1 | 10.0 | 14.0 |
| 25 | 18.0 | 23.9 | 7.6 | 4.2 | 4.7 | 4.0 | 2.0 | 1.45 | 2.5 | 2.7 | 9.5 | 13.6 |
| 26 | 14.8 | 22.9 | 7.45 | 4.1 | 4.9 | 3.95 | 2.5 | 1.45 | 1.8 | 3.2 | 8.3 | 16.0 |
| 27 | 13.2 | 22.1 | 7.1 | 4.25 | 5.0 | 3.8 | 2.0 | 1.25 | 1.4 | 5.4 | 7.2 | 13.0 |
| 28 | 13.5 | 18.9 | 6.5 | 5.25 | 4.85 | 3.65 | 2.3 | 1.3 | 1.3 | 4.5 | 7.3 | 11.9 |
| 29 | 10.7 | ..... | 6.8 | 5.35 | 4.6 | 3.9 | 2.25 | 1.2 | 1.7 | 4.2 | 6.4 | 10.2 |
| 30 | 10.4 | ..... | 6.1 | 4.2 | 4.45 | 4.3 | 2.5 | 1.15 | 1.95 | 4.1 | 6.5 | 10.5 |
| 31 | 9.0 | ..... | 7.5 | ..... | 4.6 | ..... | 2.35 | 1.3 | ..... | 4.05 | ..... | 11.4 |

*Rating table for Luckiamute River near Suver, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.90 | 39 | 2.30 | 143 | 3.70 | 306 | 6.20 | 701 | 17.00 | 3,770 |
| 1.00 | 44 | 2.40 | 153 | 3.80 | 319 | 6.40 | 737 | 18.00 | 4,148 |
| 1.10 | 50 | 2.50 | 163 | 3.90 | 333 | 6.60 | 774 | 19.00 | 4,540 |
| 1.20 | 56 | 2.60 | 173 | 4.00 | 347 | 6.80 | 812 | 20.00 | 4,944 |
| 1.30 | 62 | 2.70 | 184 | 4.20 | 375 | 7.00 | 850 | 21.00 | 5,360 |
| 1.40 | 69 | 2.80 | 195 | 4.40 | 405 | 8.00 | 1,058 | 22.00 | 5,780 |
| 1.50 | 76 | 2.90 | 206 | 4.60 | 435 | 9.00 | 1,290 | 23.00 | 6,200 |
| 1.60 | 83 | 3.00 | 218 | 4.80 | 466 | 10.00 | 1,543 | 24.00 | 6,630 |
| 1.70 | 91 | 3.10 | 230 | 5.00 | 498 | 11.00 | 1,810 | 25.00 | 7,060 |
| 1.80 | 99 | 3.20 | 242 | 5.20 | 530 | 12.00 | 2,095 | 26.00 | 7,490 |
| 1.90 | 107 | 3.30 | 254 | 5.40 | 563 | 13.00 | 2,400 | | |
| 2.00 | 115 | 3.40 | 267 | 5.60 | 597 | 14.00 | 2,716 | | |
| 2.10 | 124 | 3.50 | 280 | 5.80 | 631 | 15.00 | 3,050 | | |
| 2.20 | 133 | 3.60 | 293 | 6.00 | 665 | 16.00 | 3,404 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 5 discharge measurements made during 1905–6 and is well defined between gage heights 1.5 feet and 9.0 feet.

*Monthly discharge of Luckiamute River near Suver, Oreg., for 1905–6.*

| Month. | Discharge in second-feet. | | | Total in Acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| 1905.[a] | | | | |
| August 26–31 | 76 | 41 | 55.4 | 1,320 |
| September | 280 | 39 | 76.6 | 4,560 |
| October | 1,290 | 133 | 396 | 24,300 |
| November | 1,000 | 115 | 247 | 14,700 |
| December | 4,400 | 375 | 1,450 | 89,200 |
| The period | | | | 134,000 |
| 1906.[b] | | | | |
| January | 5,610 | 1,000 | 2,720 | 167,000 |
| February | 6,590 | 420 | 2,410 | 134,000 |
| March | 3,330 | 546 | 1,060 | 65,200 |
| April | 812 | 280 | 436 | 25,900 |
| May | 793 | 206 | 381 | 23,400 |
| June | 1,220 | 293 | 492 | 29,300 |
| July | 319 | 115 | 192 | 11,800 |
| August | 115 | 53 | 85 | 5,230 |
| September | 168 | 37 | 84.5 | 5,030 |
| October | 1,140 | 72 | 314 | 19,300 |
| November | 7,450 | 173 | 2,640 | 157,000 |
| December | 6,840 | 580 | 2,290 | 141,000 |
| The year | 7,450 | 37 | 1,090 | 784,000 |

[a] Values for 1905 are rated as follows: October, excellent; November and December, good; August and September, fair.

[b] Values for 1906 are rated as follows: April to June and October, excellent; March and July, good; remainder of the year, fair.

## MOLALLA RIVER NEAR MOLALLA, OREG.

This station was established November 1, 1905. It is located at Dickey Prairie, 3 miles below the junction of the forks of the river 3½ miles southeast of Molalla, Oreg. The conditions at the station and the bench marks are described in Water-Supply Paper No. 178, page 227.

*Discharge measurements of Molalla River near Molalla, Oreg., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| November 2 | L. R. Allen | 106 | 226 | 1.83 | 376 |
| 1906. | | | | | |
| January 9[a] | L. R. Allen | 130 | 437 | 3.63 | 1,510 |
| January 13 | P. A. Cupper | 130 | 422 | 3.55 | 1,610 |
| April 3 | L. R. Allen | 118 | 334 | 2.80 | 924 |
| May 24 | do | 117 | 323 | 2.66 | 822 |
| July 11 | do | 104 | 174 | 1.33 | 186 |
| September 4 | I. E. Oakes | 102 | 118 | .75 | 60 |

[a] Measurement unreliable.

*Daily gage height, in feet, of Molalla River near Molalla, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.7 | 3.75 | 3.75 | 3.4 | 2.7 | 2.25 | 1.9 | 1.0 | 0.75 | 1.0 | 1.85 | 2.25 |
| 2 | 2.7 | 3.5 | 3.45 | 3.0 | 2.5 | 2.15 | 1.85 | .95 | .75 | 1.05 | 1.8 | 2.15 |
| 3 | 2.75 | 3.4 | 3.7 | 2.8 | 2.4 | 2.25 | 1.8 | .95 | .75 | 1.6 | 1.75 | 2.1 |
| 4 | 2.8 | 3.3 | 3.65 | 2.7 | 2.3 | 2.5 | 1.75 | .95 | .75 | 1.55 | 2.5 | 2.05 |
| 5 | 3.15 | 2.8 | 3.45 | 2.7 | 2.2 | 2.5 | 1.65 | .9 | .75 | 1.4 | 2.6 | 2.4 |
| 6 | 3.1 | 2.7 | 3.55 | 2.7 | 2.15 | 2.75 | 1.5 | .9 | .75 | 1.35 | 2.5 | 2.5 |
| 7 | 3.05 | 2.6 | 3.6 | 2.8 | 2.1 | 2.95 | 1.45 | .9 | .75 | 1.3 | 6.8 | 3.3 |
| 8 | 3.3 | 2.5 | 3.7 | 2.7 | 2.0 | 2.85 | 1.45 | .9 | .75 | 1.1 | 6.5 | 3.65 |
| 9 | 3.7 | 2.35 | 3.8 | 2.8 | 2.0 | 2.85 | 1.4 | .9 | .75 | 1.05 | 4.9 | 3.4 |
| 10 | 3.45 | 2.3 | 3.5 | 2.7 | 1.9 | 2.75 | 1.4 | .9 | .75 | 1.0 | 5.3 | 3.0 |
| 11 | 3.5 | 2.2 | 3.3 | 2.7 | 1.85 | 2.65 | 1.35 | .9 | .75 | 1.05 | 4.4 | 3.2 |
| 12 | 3.5 | 2.15 | 3.0 | 2.7 | 1.8 | 2.55 | 1.3 | .85 | .85 | 1.65 | 4.0 | 3.4 |
| 13 | 3.55 | 2.1 | 2.7 | 2.5 | 1.75 | 2.55 | 1.3 | .85 | 1.3 | 2.2 | 7.45 | 2.8 |
| 14 | 3.5 | 2.05 | 2.65 | 2.45 | 2.15 | 2.5 | 1.25 | .9 | 2.8 | 2.65 | 8.1 | 2.7 |
| 15 | 3.7 | 2.5 | 2.45 | 2.35 | 2.4 | 3.0 | 1.2 | .9 | 2.5 | 2.2 | 8.85 | 3.4 |
| 16 | 3.9 | 2.5 | 2.3 | 2.35 | 2.35 | 4.0 | 1.2 | .85 | 1.8 | 3.6 | 6.2 | 3.9 |
| 17 | 3.9 | 3.9 | 2.25 | 2.3 | 3.3 | 3.4 | 1.2 | .85 | 1.45 | 3.9 | 6.0 | 3.2 |
| 18 | 3.95 | 5.0 | 2.2 | 2.25 | 2.3 | 3.0 | 1.2 | .85 | 1.3 | 3.3 | 5.3 | 3.2 |
| 19 | 3.45 | 4.7 | 2.15 | 2.15 | 2.6 | 2.8 | 1.2 | .85 | 1.2 | 3.1 | 4.4 | 3.5 |
| 20 | 3.1 | 5.9 | 2.1 | 2.1 | 2.7 | 2.6 | 1.15 | .8 | 1.15 | 2.75 | 4.0 | 7.5 |
| 21 | 2.9 | 5.4 | 2.1 | 2.25 | 2.75 | 2.4 | 1.15 | .8 | 1.15 | 2.5 | 3.8 | 6.0 |
| 22 | 2.95 | 4.5 | 2.05 | 2.25 | 2.8 | 2.3 | 1.15 | .8 | 1.1 | 2.35 | 3.6 | 4.6 |
| 23 | 4.85 | 4.35 | 2.0 | 2.25 | 2.85 | 2.2 | 1.15 | .8 | 1.2 | 2.1 | 3.4 | 4.2 |
| 24 | 5.2 | 4.5 | 2.2 | 2.2 | 2.65 | 2.1 | 1.1 | .8 | 1.3 | 1.95 | 3.1 | 3.6 |
| 25 | 4.5 | 4.4 | 2.1 | 3.4 | 2.5 | 1.95 | 1.1 | .8 | 1.2 | 1.9 | 2.9 | 4.2 |
| 26 | 4.0 | 4.6 | 2.35 | 3.0 | 2.65 | 1.85 | 1.1 | .8 | 1.1 | 1.95 | 2.75 | 4.5 |
| 27 | 3.75 | 4.9 | 2.45 | 2.7 | 2.6 | 1.9 | 1.1 | .75 | 1.05 | 1.95 | 2.6 | 3.9 |
| 28 | 3.5 | 4.35 | 2.4 | 3.1 | 2.5 | 1.95 | 1.1 | .75 | 1.0 | 1.95 | 2.5 | 3.5 |
| 29 | 3.5 | ..... | 2.5 | 3.05 | 2.45 | 2.05 | 1.05 | .75 | .95 | 1.9 | 2.35 | 3.4 |
| 30 | 3.7 | ..... | 2.7 | 2.85 | 2.4 | 2.0 | 1.05 | .75 | .95 | 1.85 | 2.3 | 3.3 |
| 31 | 4.0 | ..... | 3.7 | ..... | 2.35 | ..... | 1.0 | .75 | ..... | 1.85 | ..... | 3.2 |

*Rating table for Molalla River near Molalla, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.70 | 52 | 1.70 | 320 | 2.70 | 855 | 3.70 | 1,595 | 5.40 | 3,225 |
| 0.80 | 68 | 1.80 | 364 | 2.80 | 920 | 3.80 | 1,680 | 5.60 | 3,435 |
| 0.90 | 86 | 1.90 | 411 | 2.90 | 985 | 3.90 | 1,770 | 5.80 | 3,645 |
| 1.00 | 106 | 2.00 | 460 | 3.00 | 1,055 | 4.00 | 1,860 | 6.00 | 3,855 |
| 1.10 | 127 | 2.10 | 510 | 3.10 | 1,125 | 4.20 | 2,040 | 7.00 | 4,955 |
| 1.20 | 151 | 2.20 | 565 | 3.20 | 1,200 | 4.40 | 2,225 | 8.00 | 6,105 |
| 1.30 | 178 | 2.30 | 620 | 3.30 | 1,275 | 4.60 | 2,415 | 9.00 | 7,305 |
| 1.40 | 208 | 2.40 | 675 | 3.40 | 1,350 | 4.80 | 2,610 | | |
| 1.50 | 242 | 2.50 | 735 | 3.50 | 1,430 | 5.00 | 2,810 | | |
| 1.60 | 279 | 2.60 | 795 | 3.60 | 1,510 | 5.20 | 3,015 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1905–6 and is well defined between gage heights 0.75 foot and 4.0 feet.

*Monthly discharge of Molalla River near Molalla, Oreg., for 1905–6.*

[Drainage area, 220 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905.[a] | | | | | | |
| November | 1,600 | 164 | 464 | 27,600 | 2.11 | 2.35 |
| December | 2,320 | 592 | 1,190 | 73,200 | 5.41 | 6.24 |
| The period | | | | 101,000 | | |
| 1906.[b] | | | | | | |
| January | 3,020 | 855 | 1,490 | 91,600 | 6.77 | 7.80 |
| February | 3,750 | 485 | 1,580 | 87,800 | 7.18 | 7.48 |
| March | 1,680 | 460 | 986 | 60,600 | 4.48 | 5.16 |
| April | 1,350 | 510 | 830 | 49,400 | 3.77 | 4.21 |
| May | 952 | 342 | 657 | 40,400 | 2.99 | 3.45 |
| June | 1,860 | 387 | 787 | 46,800 | 3.58 | 3.99 |
| July | 411 | 106 | 191 | 11,700 | .868 | 1.00 |
| August | 106 | 60 | 77.6 | 4,770 | .353 | .407 |
| September | 920 | 60 | 164 | 9,760 | .745 | .831 |
| October | 1,770 | 106 | 512 | 31,500 | 2.33 | 2.69 |
| November | 7,120 | 242 | 2,170 | 129,000 | 9.86 | 11.00 |
| December | 5,530 | 485 | 1,510 | 92,800 | 6.86 | 7.91 |
| The year | 7,120 | 60 | 913 | 656,000 | 4.15 | 55.93 |

[a] Values for 1905 are rated as follows: November, excellent; December good.
[b] Values for 1906 are rated as follows: March to June, November and December, excellent; remainder of the year, good.

## SOUTH FORK OF YAMHILL RIVER AT SHERIDAN, OREG.

This station was established April 25, 1906. It is located in Sheridan, Oreg., about 2 miles below the mouth of Mill Creek.

The channel is straight for 250 feet above and 500 feet below the station, and the current is uniform. Both banks are high and well covered with undergrowth; the right is liable to overflow at extreme high water. The bed of the stream is of sand and fine clean gravel and is liable to shift during high water. There is one channel at all stages.

Discharge measurements are made from the public highway bridge in Sheridan. The initial point for soundings is two nails driven in the wall, about 1 foot to the left of the corner of the first building on the right bank.

The gage, which is read daily by G. Schoppert, is a 2 by 8 inch timber in two sections, the lower section being vertical, 3.8 feet long, and nailed to a cross timber on the lower side of the right bridge pier. The upper portion is inclined at a small angle and nailed to an upright timber of the pier, being 24.3 feet in length. The bench mark is the top of three 30-penny nails driven in an ash tree about 5 feet below the bridge and 25 feet from the initial point; elevation, 21.70 feet above the datum of the gage.

*Discharge measurements of South Fork of Yamhill River at Sheridan, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| December 14 | L. R. Allen | 122 | 428 | ..... | 583 |
| 1906. | | | | | |
| April 25 | L. R. Allen | 124 | 494 | 2.70 | 813 |
| May 18 | do | 123 | 453 | 2.34 | 625 |
| July 1 | do | 116 | 374 | 1.81 | 436 |
| September 7 | I. E. Oakes | 106 | 211 | .30 | 48 |
| October 30 | do | 117 | 369 | 1.80 | 423 |

*Daily gage height, in feet, of South Fork of Yamhill River at Sheridan, Oreg., for 1906.*

| Day. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 2.0 | 1.9 | 1.9 | .8 | .3 | ..... | 2.0 | 2.5 |
| 2 | ..... | 2.0 | 1.8 | 1.65 | .7 | .3 | ..... | 2.0 | 2.5 |
| 3 | ..... | 1.9 | 1.8 | 1.5 | .7 | .3 | ..... | 2.0 | 2.4 |
| 4 | ..... | 2.3 | 2.9 | 1.5 | .7 | .2 | ..... | 2.0 | 2.3 |
| 5 | ..... | 2.3 | 2.9 | 1.45 | .6 | .3 | ..... | 4.0 | 2.3 |
| 6 | ..... | 2.2 | 2.9 | 1.45 | .6 | .3 | ..... | 4.3 | 2.3 |
| 7 | ..... | 2.1 | 3.1 | 1.4 | .6 | .3 | ..... | 7.9 | 8.5 |
| 8 | ..... | 2.9 | 2.8 | 1.4 | .6 | .4 | ..... | 12.0 | 6.0 |
| 9 | ..... | 2.8 | 2.75 | 1.3 | .6 | .4 | ..... | 8.1 | 6.0 |
| 10 | ..... | 2.7 | 2.4 | 1.3 | .5 | .4 | ..... | 9.0 | 5.5 |
| 11 | ..... | 2.6 | 2.5 | 1.3 | .5 | .5 | ..... | 8.0 | 5.5 |
| 12 | ..... | 2.5 | 3.0 | 1.35 | .5 | .6 | ..... | 7.8 | 5.3 |
| 13 | ..... | 1.7 | 3.9 | 1.2 | .5 | 1.4 | ..... | 7.5 | 5.2 |
| 14 | ..... | 1.7 | 4.0 | 1.1 | .6 | 1.6 | ..... | 8.5 | 4.0 |
| 15 | ..... | 2.3 | 3.8 | 1.1 | .5 | 1.7 | ..... | 14.5 | 4.5 |
| 16 | ..... | 2.3 | 5.0 | 1.0 | .5 | 1.7 | ..... | 8.5 | 5.5 |
| 17 | ..... | 2.5 | 4.0 | 1.0 | .5 | 1.6 | ..... | 9.5 | 5.5 |
| 18 | ..... | 2.4 | 3.6 | 1.0 | .5 | 1.0 | ..... | 8.5 | 4.4 |
| 19 | ..... | 2.3 | 3.4 | 1.0 | .5 | .9 | ..... | 7.0 | 4.6 |
| 20 | ..... | 2.2 | 3.0 | 1.0 | .4 | .7 | ..... | 7.0 | 11.4 |
| 21 | ..... | 2.1 | 2.8 | .9 | .4 | .7 | ..... | 5.5 | 11.6 |
| 22 | ..... | 2.0 | 2.6 | .9 | .4 | .6 | ..... | 5.3 | 7.3 |
| 23 | ..... | 1.9 | 2.4 | .9 | .4 | .7 | ..... | 5.0 | 7.0 |
| 24 | ..... | 2.0 | 2.2 | .9 | .4 | .9 | ..... | 4.6 | 5.9 |
| 25 | 2.6 | 2.5 | 2.0 | .9 | .4 | 1.3 | ..... | 4.0 | 6.8 |
| 26 | 2.3 | 2.5 | 1.9 | .8 | .4 | 1.0 | ..... | 4.0 | 5.8 |
| 27 | 2.4 | 2.9 | 1.9 | .8 | .4 | .9 | ..... | 3.5 | 5.8 |
| 28 | 2.5 | 2.3 | 1.95 | .8 | .3 | .8 | ..... | 3.0 | 5.3 |
| 29 | 2.3 | 2.2 | 1.8 | .8 | .3 | .8 | ..... | 2.8 | 4.5 |
| 30 | 2.2 | 2.1 | 2.1 | .9 | .3 | ..... | 1.8 | 2.5 | 4.8 |
| 31 | ..... | 2.1 | ..... | .8 | .3 | ..... | 1.9 | ..... | 4.5 |

*Rating table for South Fork of Yamhill River at Sheridan, Oreg., from April 25 to September 30, 1906.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.20 | 38 | 1.10 | 208 | 2.00 | 500 | 2.90 | 895 | 3.80 | 1,395 |
| 0.30 | 51 | 1.20 | 235 | 2.10 | 540 | 3.00 | 945 | 3.90 | 1,455 |
| 0.40 | 65 | 1.30 | 264 | 2.20 | 580 | 3.10 | 995 | 4.00 | 1,515 |
| 0.50 | 80 | 1.40 | 294 | 2.30 | 620 | 3.20 | 1,050 | 4.20 | 1,645 |
| 0.60 | 97 | 1.50 | 326 | 2.40 | 665 | 3.30 | 1,105 | 4.40 | 1,775 |
| 0.70 | 116 | 1.60 | 359 | 2.50 | 710 | 3.40 | 1,160 | 4.60 | 1,915 |
| 0.80 | 137 | 1.70 | 393 | 2.60 | 755 | 3.50 | 1,215 | 4.80 | 2,055 |
| 0.90 | 159 | 1.80 | 428 | 2.70 | 800 | 3.60 | 1,275 | 5.00 | 2,200 |
| 1.00 | 183 | 1.90 | 464 | 2.80 | 845 | 3.70 | 1,335 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 4 discharge measurements made during 1906 and is not well defined.

*Monthly discharge of South Fork of Yamhill River at Sheridan, Oreg., for 1906.*

[Drainage area, 290 square miles.]

| Month. | Discharge in second-feet. | | | Run-off. | | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Total in acre-feet. | Sec.-ft. per sq. mile. | Depth in inches. |
| April 25–30 | 755 | 580 | 658 | 7,830 | 2.27 | .51 |
| May | 895 | 393 | 614 | 37,800 | 2.12 | 2.44 |
| June | 2,200 | 428 | 873 | 51,900 | 3.01 | 3.36 |
| July | 464 | 137 | 225 | 13,800 | .776 | .90 |
| August | 137 | 51 | 81.0 | 4,980 | .279 | .32 |
| September | 393 | 38 | 149 | 8,870 | .514 | .57 |
| The period | | | | 125,000 | | |

NOTE.—The above estimates are provisional and subject to revision when more data are available. Values are rated as follows: April to June, good; July to September, fair.

## CLACKAMAS RIVER NEAR BARTON, OREG.

This station was established October 2, 1905. It is located 2½ miles below Barton, Oreg., 1½ miles below the mouth of Deep Creek. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 228.

*Discharge measurements of Clackamas River near Barton, Oreg., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| October 2 | L. R. Allen | 310 | 704 | 3.30 | 1,600 |
| 1906. | | | | | |
| January 8 | L. R. Allen | 310 | 1,070 | 4.52 | 3,310 |
| January 13 | do | 325 | 1,160 | 4.84 | 4,020 |
| April 2 | do | 324 | 1,290 | 5.18 | 4,950 |
| May 23 | do | 304 | 1,010 | 4.30 | 3,250 |
| July 10 | do | 276 | 640 | 3.01 | 1,270 |
| September 3 | Ivan Oakes | 265 | 497 | 2.51 | 817 |

*Daily gage height, in feet, of Clackamas River near Barton, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.4 | 5.6 | 5.6 | 5.9 | 4.9 | 3.8 | 3.4 | 2.7 | 2.52 | 2.6 | 3.2 | 4.5 |
| 2 | 4.3 | 5.4 | 5.3 | 5.3 | 4.7 | 3.8 | 3.4 | 2.7 | 2.52 | 2.7 | 3.1 | 4.5 |
| 3 | 4.1 | 5.2 | 5.3 | 4.9 | 4.5 | 3.8 | 3.3 | 2.7 | 2.52 | 2.8 | 3.1 | 4.5 |
| 4 | 4.1 | 4.9 | 5.1 | 4.7 | 4.5 | 4.1 | 3.2 | 2.7 | 2.52 | 3.0 | 3.2 | 4.4 |
| 5 | 4.36 | 4.7 | 5.0 | 4.7 | 4.4 | 4.0 | 3.2 | 2.7 | 2.52 | 2.9 | 3.7 | 4.4 |
| 6 | 4.45 | 4.5 | 5.0 | 4.8 | 4.3 | 4.2 | 3.1 | 2.65 | 2.51 | 2.8 | 3.5 | 4.6 |
| 7 | 4.52 | 4.4 | 5.0 | 5.0 | 4.2 | 4.5 | 3.1 | 2.65 | 2.51 | 2.7 | 7.15 | 6.0 |
| 8 | 4.5 | 4.2 | 5.1 | 5.1 | 4.2 | 4.3 | 3.1 | 2.65 | 2.51 | 2.7 | 10.0 | 6.5 |
| 9 | 4.9 | 4.1 | 5.3 | 5.5 | 4.2 | 4.5 | 3.0 | 2.6 | 2.51 | 2.7 | 7.0 | 6.0 |
| 10 | 4.9 | 4.0 | 5.4 | 5.3 | 4.2 | 4.2 | 3.0 | 2.6 | 2.51 | 2.6 | 6.3 | 5.7 |
| 11 | 4.9 | 3.9 | 5.2 | 5.0 | 4.1 | 4.2 | 3.0 | 2.6 | 2.51 | 2.6 | 6.6 | 5.6 |
| 12 | 4.9 | 3.8 | 4.8 | 4.7 | 4.1 | 4.1 | 3.0 | 2.6 | 2.54 | 2.7 | 5.7 | 5.3 |
| 13 | 4.9 | 3.8 | 4.6 | 4.6 | 3.9 | 4.1 | 3.0 | 2.6 | 2.8 | 2.8 | 10.1 | 5.1 |
| 14 | 4.7 | 3.7 | 4.5 | 4.6 | 3.8 | 4.0 | 3.0 | 2.6 | 3.3 | 3.1 | 10.6 | 5.0 |
| 15 | 4.6 | 3.8 | 4.4 | 4.6 | 4.3 | 4.0 | 3.0 | 2.6 | 4.1 | 3.1 | 11.9 | 4.9 |
| 16 | 4.6 | 3.9 | 4.1 | 4.7 | 4.2 | 5.3 | 3.0 | 2.6 | 3.3 | 4.3 | 10.7 | 6.6 |
| 17 | 4.9 | 4.0 | 4.1 | 4.7 | 4.0 | 5.0 | 3.0 | 2.6 | 3.0 | 4.6 | 10.5 | 6.1 |
| 18 | 5.1 | 5.8 | 4.0 | 4.5 | 4.0 | 4.7 | 3.0 | 2.6 | 2.8 | 4.7 | 8.6 | 5.7 |
| 19 | 4.75 | 8.2 | 3.9 | 4.5 | 3.9 | 4.5 | 3.0 | 2.6 | 2.75 | 4.4 | 7.0 | 5.9 |
| 20 | 4.5 | 7.1 | 3.9 | 4.5 | 4.0 | 4.2 | 3.0 | 2.55 | 2.7 | 4.0 | 6.5 | 11.0 |

*Daily gage height, in feet, of Clackamas River, near Barton, Oreg., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 4.3 | 8.0 | 3.9 | 4.9 | 4.2 | 3.9 | 3.0 | 2.55 | 2.65 | 3.7 | 6.5 | 11.0 |
| 22 | 4.2 | 7.0 | 3.8 | 4.8 | 4.3 | 3.9 | 3.0 | 2.55 | 2.65 | 3.5 | 6.2 | 9.0 |
| 23 | 4.7 | 6.4 | 3.8 | 4.8 | 4.3 | 3.7 | 3.0 | 2.55 | 2.65 | 3.4 | 6.0 | 7.0 |
| 24 | 7.2 | 6.1 | 3.9 | 4.7 | 4.2 | 3.6 | 2.9 | 2.55 | 2.65 | 3.3 | 5.8 | 6.5 |
| 25 | 6.7 | 6.4 | 3.9 | 4.9 | 4.2 | 3.5 | 2.8 | 2.55 | 2.65 | 3.2 | 5.3 | 7.0 |
| 26 | 6.0 | 6.1 | 4.2 | 5.3 | 4.3 | 3.5 | 2.8 | 2.55 | 2.64 | 3.3 | 5.1 | 7.5 |
| 27 | 5.6 | 6.8 | 4.2 | 4.9 | 4.3 | 3.4 | 2.7 | 2.55 | 2.63 | 3.4 | 4.9 | 7.5 |
| 28 | 5.3 | 6.1 | 4.2 | 5.1 | 4.2 | 3.5 | 2.7 | 2.55 | 2.62 | 3.5 | 4.8 | 6.8 |
| 29 | 5.2 | ..... | 4.2 | 5.1 | 4.0 | 3.5 | 2.7 | 2.54 | 2.61 | 3.4 | 4.7 | 6.2 |
| 30 | 5.3 | ..... | 4.4 | 5.0 | 4.0 | 3.6 | 2.7 | 2.53 | 2.6 | 3.2 | 4.6 | 6.1 |
| 31 | 5.6 | ..... | 5.7 | ..... | 3.9 | ..... | 2.7 | 2.53 | ..... | 3.2 | ..... | 5.9 |

*Rating table for Clackamas River near Barton, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 2.50 | 810 | 3.50 | 1,860 | 4.50 | 3,480 | 5.50 | 5,560 | 7.00 | 9,460 |
| 2.60 | 890 | 3.60 | 2,000 | 4.60 | 3,670 | 5.60 | 5,790 | 7.20 | 10,040 |
| 2.70 | 970 | 3.70 | 2,140 | 4.70 | 3,860 | 5.70 | 6,030 | 7.40 | 10,620 |
| 2.80 | 1,060 | 3.80 | 2,290 | 4.80 | 4,050 | 5.80 | 6,270 | 7.60 | 11,220 |
| 2.90 | 1,160 | 3.90 | 2,450 | 4.90 | 4,250 | 5.90 | 6,510 | 7.80 | 11,820 |
| 3.00 | 1,260 | 4.00 | 2,610 | 5.00 | 4,460 | 6.00 | 6,760 | 8.00 | 12,430 |
| 3.10 | 1,370 | 4.10 | 2,780 | 5.10 | 4,670 | 6.20 | 7,270 | 9.00 | 15,530 |
| 3.20 | 1,480 | 4.20 | 2,950 | 5.20 | 4,890 | 6.40 | 7,790 | 10.00 | 18,730 |
| 3.30 | 1,600 | 4.30 | 3,120 | 5.30 | 5,110 | 6.60 | 8,330 | 11.00 | 22,030 |
| 3.40 | 1,730 | 4.40 | 3,300 | 5.40 | 5,330 | 6.80 | 8,890 | 12.00 | 25,430 |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 7 discharge measurements made during 1905–6 and is well defined below gage height 5.5 feet.

*Monthly discharge of Clackamas River near Barton, Oreg., for 1905–6.*

[Drainage area, 800 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905.[a] | | | | | | |
| November 11–30 | 3,860 | 1,160 | 2,060 | 81,700 | 2.58 | 1.92 |
| December | 5,490 | 2,290 | 3,800 | 234,000 | 4.75 | 5.48 |
| The period | ..... | ..... | ..... | 316,000 | ..... | ..... |
| 1906.[b] | | | | | | |
| January | 10,000 | 2,780 | 4,400 | 271,000 | 5.50 | 6.34 |
| February | 13,000 | 2,140 | 5,430 | 302,000 | 6.79 | 7.07 |
| March | 6,030 | 2,290 | 3,700 | 228,000 | 4.62 | 5.33 |
| April | 6,510 | 3,480 | 4,280 | 255,000 | 5.35 | 5.97 |
| May | 4,250 | 2,290 | 2,960 | 182,000 | 3.70 | 4.27 |
| June | 5,110 | 1,730 | 2,730 | 162,000 | 3.41 | 3.80 |
| July | 1,730 | 970 | 1,260 | 77,500 | 1.58 | 1.82 |
| August | 970 | 834 | 890 | 54,700 | 1.11 | 1.28 |
| September | 2,780 | 818 | 1,010 | 60,100 | 1.26 | 1.41 |
| October | 3,860 | 890 | 1,650 | 101,000 | 2.06 | 2.38 |
| November | 25,100 | 1,370 | 8,720 | 519,000 | 10.90 | 12.16 |
| December | 22,000 | 3,300 | 7,690 | 473,000 | 9.61 | 11.08 |
| The year | 25,100 | 818 | 3,730 | 2,690,000 | 4.66 | 62.91 |

[a] Values for 1905 are rated as excellent.
[b] Values for 1906 are rated as follows: January to October, excellent; November and December, good.

MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in Willamette River drainage basin in 1906:

*Boulder Creek near Detroit, Oreg.*—The flow of this stream was estimated September 5, 1906, at 5 second-feet.

*Breitenbush Creek near Detroit, Oreg.*—A measurement was made at low water, September 4, 1906, just above the mouth of the creek.

Width, 59 feet; area, 100 square feet; discharge, 184 second-feet.

*Calapooia Creek.*—A measurement was made 300 yards below Kendall's bridge in sec. 19, T. 12 S., R. 3 W., at low water, August 23, 1906.

Width, 50 feet; area, 38 square feet; discharge, 64 second-feet.

*Crabtree Creek near Thomas, Oreg.*—A measurement was made 100 yards below the bridge in sec. 27, T. 10 S., R. 2 W., at low water August 24, 1906.

Width, 51 feet; area, 59 square feet; discharge, 55 second-feet.

*Long Tom Creek near Junction City, Oreg.*—A measurement was made 75 feet above the highway bridge, in sec. 10, T. 16 S., R. 5 W., at low water August 18, 1906.

Width, 42 feet; area, 29 square feet; discharge, 22 second-feet.

*Marys Creek near Philamath, Oreg.*—A measurement was made at the bridge in sec. 11, T. 12 S., R. 6 W., at low water August 25, 1906.

Width, 50 feet; area, 31 square feet; discharge, 18 second-feet.

*Minto Creek.*—The two channels of this stream were measured in sec. 10, T. 11 S., R. 7 E., at low water September 6, 1906.

The surface of the right channel was 3.22 feet below a spike in a large cedar just upstream from the trail crossing.

Width, 10 feet; area, 3.7 square feet; discharge, 3.7 second-feet.

The water surface of the left channel was 3.35 feet below a nail in a 10-inch cedar on the right bank just above the trail crossing.

Width, 7 feet; area, 3.3 square feet; discharge, 6.7 second-feet.

*Mohawk River near Mohawk, Oreg.*—A measurement was made by wading, August 16, 1906, 50 feet above the highway bridge in sec. 9, T. 17 S., R. 2 W.

Width, 62 feet; area, 64 square feet; discharge, 37 second-feet.

*Permelia Creek.*—A measurement was made in sec. 33, T. 10 S., R. 7 E., at low water, September 6, 1906. The water surface was 5.20 feet below a nail in a 6-inch alder 30 feet upstream from the Minto trail crossing.

Width, 39 feet; area, 32 square feet; discharge, 80 second-feet.

*Roaring Creek.*—This stream is very rocky and rough and has an enormous fall. A measurement was made in T. 11 S., R. 7 E., at low water, September 7, 1906. The water surface was 3.84 feet below a spike in an 18-inch alder on the right bank near the Minto trail crossing.

Width, 19 feet; area, 26 square feet; discharge, 65 second-feet.

*Santiam River at Jefferson, Oreg.*—This station is described in Water-Supply Paper 178, page 224. Gage readings were discontinued during 1906, as the flow was obstructed by logs. The following measurements were made during 1906:

January 3, width, 314 feet; area, 3,060 square feet; gage height, 4.76 feet; discharge, 5,790 second-feet.

March 30, width, 311 feet; area, 2,950 square feet; gage height, 5.50 feet; discharge, 6,170 second-feet.

*Marion Fork of Santiam River.*—A measurement was made in sec. 15, T. 11 S., R. 7 E., at low water, September 6, 1906. The water surface was 4.76 feet below a spike in a yew tree on the right bank, 30 feet upstream from the foot log.

Width, 52 feet; area, 91 square feet; discharge, 157 second-feet.

A measurement was made September 7, 1906, 200 feet below the outlet of Lake Marion. The water surface was 4.45 feet below a spike in a small alder, on the right bank 30 feet downstream from water-right notice.

Width, 31 feet; area, 51 square feet; discharge, 77 second-feet.

*Middle Fork of Santiam River.*—The following measurement was made near Foster, Oreg., at low water, September 3, 1906.

Width, 96 feet; area, 183 square feet; discharge, 66 second-feet.

The following measurement was made at Withcombe Place, Oreg., at low water, September 4, 1906.

Width, 60 feet; area, 144 square feet; discharge, 82 second-feet.

*North Fork of North Fork of Santiam River near Mehama, Oreg.*—A measurement was made in sec. 18, T. 9 S., R. 2 E., at old fort one-half mile above Mehama, at low water, August 21, 1906.

Width, 59 feet; area, 40 square feet; discharge, 54 second-feet.

*North Fork of Santiam River in sec. 12, T. 10 S., R. 5 E.*—A measurement was made at low water, August 22, 1906, opposite the mill above Detroit, Oreg.

Width, 58 feet; area, 387 square feet; discharge, 469 second-feet.

A measurement was made September 4, 1906, below the mouth of Breitenbush Creek. The water surface was 3.68 feet below a spike in the upstream face of the foot log near the right bank.

Width, 110 feet; area, 282 square feet; discharge, 564 second-feet.

A measurement was made September 5, 1906, above the mouth of Breitenbush Creek. The water surface was 5.95 feet below a shelf cut into rock on the right bank for a brace to the footbridge.

Width, 60 feet; area, 456 square feet; discharge, 433 second-feet.

*North Fork of Santiam River T. 11 S., R. 7 E.*—A measurement was made above the mouth of Marion Fork, September 6, 1906, at low water.

East channel, width, 30 feet; area, 45 square feet; discharge, 43 second-feet. West channel, width, 36 feet; area, 44 square feet; discharge, 53 second-feet.

*South Fork of Santiam River.*—A measurement was made 150 yards below Sanderson bridge in sec. 4, T. 11 S., R. 2 W., on August 24, 1906.

Width, 76 feet; area, 50 square feet; discharge, 51 second-feet.

A measurement was made at Foster, September 3, 1906.

Width, 87 feet; area, 163 square feet; discharge, 131 second-feet.

A measurement was made at Withcombe Place, September 3, 1906.

Width, 60 feet; area, 144 square feet; discharge, 82 second-feet.

*Thomas Fork of Santiam River at Scio, Oreg.*—A measurement was made above the bridge in sec. 18, T. 10 S., R. 1 W., August 24, 1906.

Width, 34 feet; area, 28 square feet; discharge, 28 second-feet.

*Whitewater Creek in SW. ¼ sec. 21, T. 10 S., R. 7 E.*—A measurement was made one-fourth mile above the mouth September 6, 1906. The water surface was 4.49 feet below the reference point on a cedar tree 100 feet upstream from a log cabin near the Minto trail.

Width, 32 feet; area, 28 square feet; discharge, 65 second-feet.

## PUGET SOUND DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

The streams flowing into Puget Sound drain the western slope of the Cascade Mountains in Washington. Their areas are heavily timbered and mountainous. The precipitation is high, varying from 40 to 100 inches per annum. The streams draining this area are principally valuable for power and logging purposes. Little or no irrigation is practiced.

### SNOHOMISH RIVER DRAINAGE BASIN.

#### SNOQUALMIE RIVER NEAR SNOQUALMIE FALLS, WASH.

Snoqualmie and Skykomish rivers unite to form Snohomish River, which flows into Puget Sound about 10 miles beyond the junction, near Everett, Wash. The following gage heights were furnished by the Seattle-Tacoma Power Company, of Seattle, Wash. The gage is referred to mean sea datum and is not the one referred to in Water-Supply and Irrigation Paper No. 178, page 233.

*Daily gage height, in feet, of Snoqualmie River near Snoqualmie Falls, Wash., for 1906.*

| Day. | Nov. | Dec. | Day. | Nov. | Dec. | Day. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| 1 | 561.8 | 561.2 | 12 | 565.9 | 561.9 | 23 | 561.9 | 563.6 |
| 2 | 561.3 | 561.6 | 13 | 566.6 | 561.9 | 24 | 561.7 | 562.9 |
| 3 | 561.1 | 561.3 | 14 | 570.0 | 561.3 | 25 | 561.5 | 562.8 |
| 4 | 561.6 | 561.5 | 15 | 570.2 | 561.5 | 26 | 561.5 | 562.0 |
| 5 | 561.7 | 562.0 | 16 | 570.0 | 562.0 | 27 | 561.6 | 561.8 |
| 6 | 561.9 | 562.4 | 17 | 564.2 | 562.8 | 28 | 561.6 | 561.7 |
| 7 | 562.8 | 563.0 | 18 | 563.4 | 562.5 | 29 | 561.6 | 561.7 |
| 8 | 562.6 | 562.4 | 19 | 562.9 | 563.0 | 30 | 561.6 | 561.7 |
| 9 | 563.0 | 562.4 | 20 | 562.4 | 564.6 | 31 | | 561.7 |
| 10 | 564.5 | 561.9 | 21 | 562.3 | 564.5 | | | |
| 11 | 563.0 | 561.9 | 22 | 562.2 | 563.9 | | | |

## WHITE RIVER DRAINAGE BASIN.

White River rises near Mount Rainier and flows into Puget Sound near Seattle. Cedar River is a branch of White River.

### CEDAR RIVER NEAR RAVENSDALE, WASH.

This station was established September 27, 1902. It is located at the intake of the Seattle waterworks pipe line and is 15 miles below Cedar Lake, 4 miles from the Northern Pacific Railway at Ravensdale, and 6 miles from the Columbia and Puget Sound Railway at Maple Valley. The discharge of the pipe line is practically constant at 34 second-feet. The conditions at this station and the bench marks are described in Water-Supply Paper No. 178, page 230, where are given also references to publications that contain data for previous years.

The following measurement was made October 21, 1906:

Width, 128 feet; area, 1,060 square feet; gage height, 1.40 feet; discharge, 864 second-feet.

*Daily gage height, in feet, of Cedar River near Ravensdale, Wash., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.30 | 2.18 | 1.56 | 1.39 | 1.30 | 1.13 | 1.09 | 0.62 | 0.55 | 0.58 | 1.38 | 1.17 |
| 2 | 1.26 | 2.14 | 1.47 | 1.41 | 1.31 | 1.15 | 1.07 | .63 | .57 | .60 | 1.32 | 1.88 |
| 3 | 1.21 | 2.07 | 1.39 | 1.36 | 1.27 | 1.07 | 1.04 | .62 | .57 | .62 | 1.20 | 1.08 |
| 4 | 1.31 | 1.96 | 1.31 | 1.29 | 1.26 | 1.18 | 1.01 | .63 | .56 | .66 | 1.18 | 1.07 |
| 5 | 1.48 | 1.92 | 1.28 | 1.26 | 1.21 | 1.12 | .97 | .65 | .57 | .62 | 1.12 | 1.09 |
| 6 | 1.83 | 1.77 | 1.26 | 1.27 | 1.16 | 1.14 | .93 | .65 | .57 | 1.20 | 1.08 | 1.25 |
| 7 | 1.76 | 1.64 | 1.27 | 1.33 | 1.13 | 1.15 | .90 | .63 | .59 | 1.14 | 1.21 | 1.64 |
| 8 | 1.76 | 1.56 | 1.30 | 1.37 | 1.10 | 1.12 | .89 | .62 | .60 | 1.00 | 1.40 | 1.70 |
| 9 | 1.71 | 1.47 | 1.35 | 1.48 | 1.10 | 1.11 | .87 | .61 | .59 | 1.06 | 1.50 | 1.64 |
| 10 | 1.64 | 1.42 | 1.41 | 1.42 | 1.13 | 1.10 | .86 | .61 | .58 | 1.14 | 1.71 | 1.57 |
| 11 | 1.51 | 1.36 | 1.40 | 1.36 | 1.10 | 1.12 | .82 | .60 | .58 | 1.25 | 2.00 | 1.44 |
| 12 | 1.47 | 1.31 | 1.37 | 1.33 | 1.08 | 1.13 | .82 | .60 | .61 | 1.32 | 2.20 | 1.36 |
| 13 | 1.45 | 1.29 | 1.30 | 1.26 | 1.09 | 1.12 | .82 | .60 | .64 | 1.35 | 3.64 | 1.27 |
| 14 | 1.37 | 1.26 | 1.25 | 1.22 | 1.08 | 1.11 | .77 | .61 | .72 | 1.42 | 6.77 | 1.26 |
| 15 | 1.31 | 1.20 | 1.20 | 1.19 | 1.04 | 1.13 | .75 | .60 | .64 | 1.43 | 8.65 | 1.27 |
| 16 | 1.28 | 1.18 | 1.19 | 1.18 | 1.13 | 1.21 | .74 | .59 | .60 | 1.55 | 6.35 | 1.64 |
| 17 | 1.29 | 1.20 | 1.16 | 1.21 | 1.11 | 1.16 | .72 | .60 | .58 | 1.60 | 4.10 | 1.65 |
| 18 | 1.25 | 1.31 | 1.14 | 1.21 | 1.06 | 1.12 | .72 | .59 | .59 | 1.54 | 3.11 | 1.62 |
| 19 | 1.21 | 1.92 | 1.10 | 1.20 | 1.07 | 1.15 | .69 | .60 | .57 | 1.41 | 2.55 | 1.72 |
| 20 | 1.17 | 1.99 | 1.07 | 1.19 | 1.05 | 1.09 | .68 | .60 | .57 | 1.40 | 2.22 | 2.73 |

*Daily gage height, in feet, of Cedar River near Ravensdale, Wash., for 1906*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 1.15 | 2.06 | 1.05 | 1.27 | 1.04 | 1.12 | .67 | .59 | .56 | 1.29 | 2.10 | 3.02 |
| 22 | 1.23 | 1.95 | 1.05 | 1.37 | 1.04 | 1.14 | .66 | .58 | .55 | 1.20 | 1.91 | 2.85 |
| 23 | 1.68 | 1.85 | 1.04 | 1.44 | 1.08 | 1.12 | .65 | .57 | .57 | 1.15 | 1.71 | 2.52 |
| 24 | 2.25 | 1.84 | 1.02 | 1.38 | 1.07 | 1.06 | .65 | .59 | .60 | 1.06 | 1.58 | 2.20 |
| 25 | 2.67 | 1.76 | 1.01 | 1.35 | 1.02 | 1.05 | .63 | .58 | .59 | 1.25 | 1.52 | 2.02 |
| 26 | 2.47 | 1.78 | 1.01 | 1.31 | 1.06 | 1.04 | .63 | .58 | .58 | 2.11 | 1.47 | 1.83 |
| 27 | 2.25 | 1.71 | 1.07 | 1.28 | 1.04 | 1.01 | .66 | .56 | .58 | 2.24 | 1.39 | 1.77 |
| 28 | 2.10 | 1.67 | 1.04 | 1.26 | 1.06 | 1.01 | .65 | .58 | .57 | 1.94 | 1.24 | 1.64 |
| 29 | 2.01 | ..... | 1.03 | 1.25 | 1.03 | 1.13 | .63 | .57 | .57 | 1.73 | 1.18 | 1.60 |
| 30 | 2.00 | ..... | 1.04 | 1.27 | 1.02 | 1.11 | .64 | .57 | .57 | 1.59 | 1.77 | 1.50 |
| 31 | 2.10 | ..... | 1.29 | ..... | 1.14 | ..... | .63 | .57 | ..... | 1.47 | ..... | 1.45 |

NOTE.—These gage heights were read with a hook gage and give the height above the crest of the diversion dam of the Seattle water-system pipe line

*Rating table for Cedar River near Ravensdale, Wash., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.50 | 180 | 1.60 | 910 | 2.70 | 1,940 | 3.70 | 3,100 | 5.40 | 5,450 |
| 0.60 | 230 | 1.70 | 990 | 2.80 | 2,050 | 3.80 | 3,220 | 5.60 | 5,750 |
| 0.70 | 285 | 1.80 | 1,075 | 2.90 | 2,160 | 3.90 | 3,350 | 5.80 | 6,050 |
| 0.80 | 340 | 1.90 | 1,160 | 3.00 | 2,270 | 4.00 | 3,480 | 6.00 | 6,370 |
| 0.90 | 400 | 2.00 | 1,250 | 3.10 | 2,380 | 4.20 | 3,740 | 6.20 | 6,690 |
| 1.00 | 465 | 2.10 | 1,340 | 3.20 | 2,500 | 4.40 | 4,000 | 6.40 | 7,010 |
| 1.10 | 530 | 2.20 | 1,430 | 3.30 | 2,620 | 4.60 | 4,280 | 6.60 | 7,330 |
| 1.20 | 600 | 2.30 | 1,530 | 3.40 | 2,740 | 4.80 | 4,560 | 6.80 | 7,660 |
| 1.30 | 675 | 2.40 | 1,630 | 3.50 | 2,860 | 5.00 | 4,850 | 7.00 | 8,000 |
| 1.40 | 750 | 2.50 | 1,730 | 3.60 | 2,980 | 5.20 | 5,150 | 8.00 | 9,700 |
| 1.50 | 830 | 2.60 | 1,830 | | | | | | |

NOTE.—The above table is computed for discharges over a steel-shod triangular weir 120 feet long, which approximates in shape type O in Hazen and Whipple's discussion of irregular weirs. It includes the discharge of the Seattle water-supply pipe line.

*Monthly discharge of Cedar River near Ravensdale, Wash., for 1905–6.*

[Drainage area, 170 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| January | 1,010 | 376 | 623 | 38,300 | 3.66 | 4.22 |
| February | 1,010 | 280 | 535 | 29,700 | 3.15 | 3.28 |
| March | 1,070 | 420 | 742 | 45,600 | 4.36 | 5.03 |
| April | 870 | 485 | 618 | 36,800 | 3.64 | 4.06 |
| May | 1,980 | 406 | 807 | 49,600 | 4.75 | 5.48 |
| June | 1,190 | 394 | 656 | 39,000 | 3.86 | 4.31 |
| July | 472 | 274 | 336 | 20,700 | 1.98 | 2.28 |
| August | 268 | 180 | 236 | 14,500 | 1.39 | 1.60 |
| September | 246 | 195 | 215 | 12,800 | 1.26 | 1.41 |
| October | 1,230 | 180 | 710 | 43,700 | 4.18 | 4.82 |
| November | 950 | 290 | 478 | 28,400 | 2.81 | 3.14 |
| December | 1,070 | 524 | 728 | 44,800 | 4.28 | 4.93 |
| The year | 1,980 | 180 | 557 | 404,000 | 3.28 | 44.56 |
| 1906. | | | | | | |
| January | 1,910 | 565 | 950 | 58,400 | 5.59 | 6.44 |
| February | 1,410 | 586 | 976 | 54,200 | 5.74 | 5.98 |
| March | 878 | 472 | 610 | 37,500 | 3.59 | 4.14 |
| April | 814 | 586 | 678 | 40,300 | 3.99 | 4.45 |
| May | 682 | 478 | 538 | 33,100 | 3.16 | 3.64 |
| June | 608 | 472 | 540 | 32,100 | 3.18 | 3.55 |
| July | 524 | 246 | 334 | 20,500 | 1.96 | 2.26 |
| August | 258 | 210 | 231 | 14,200 | 1.36 | 1.57 |
| September | 296 | 205 | 224 | 13,300 | 1.32 | 1.47 |
| October | 1,470 | 220 | 688 | 42,300 | 4.05 | 4.67 |
| November | 10,800 | 517 | 1,870 | 111,000 | 11.00 | 12.27 |
| December | 2,290 | 510 | 1,010 | 62,100 | 5.95 | 6.86 |
| The year | 10,800 | 205 | 721 | 519,000 | 4.24 | 57.30 |

NOTE.—Values for 1905–6 are rated as good. Discharge includes 34 second-feet diverted by the Seattle water supply pipe line.

### MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in Puget Sound drainage basin during 1906:

*Baker River near Baker, Wash.*—A measurement was made November 5, 1906, at the highway bridge between Baker and Concrete. The water surface was 24.25 feet below the top of the first floor beam from the left downstream pier. The stage was about 3 feet above low water, and 15 feet below high water.

Width, 150 feet; area, 737 square feet; discharge, 3,180 second-feet.

*Creeks near Baker, Wash.*—The discharge of the first creek below the head-gate of the Washington Portland Cement Company's power flume was estimated November 5, 1906, as 8 second-feet. This stream is a series of cascades. The discharge of the second from the head-gate was estimated as 6 second-feet.

*Carbon River.*—This stream rises in Mount Rainier and flows into Puyallup River. It is a glacial stream and is always white with suspended matter. A measurement was made near the mouth of Canada Creek, September 26, 1906, which was not low water for the season.

Width, 31 feet; area, 54 square feet; discharge, 145 second-feet.

A measurement was made September 27, 1906, at the railroad bridge at Fairfax, Wash. The water surface was 8.55 feet below the top of the retaining wall forming the right abutment downstream side.

Width, 54 feet; area, 103 square feet; discharge, 455 second-feet.

*Canada Creek.*—This stream is a tributary of Carbon River. A measurement was made near the mouth September 26, 1906. The water surface was 3.52 feet below a nail in a small cedar near the mouth.

Width, 7 feet; area, 3.2 square feet; discharge, 5.5 second-feet.

*Chenuis Creek.*—A measurement was made near the junction with Carbon River, September 27, 1906.

Width, 14 feet; area, 14 square feet; discharge, 15 second-feet.

## NORTHERN PACIFIC OCEAN DRAINAGE.

### DESCRIPTION OF BASIN.

The streams draining the western slope of the Coast Range in Oregon are comparatively short, but, owing to the heavy precipitation on their catchment basins, carry large quantities of water. The area throughout this region is mountainous and heavily timbered. A considerable portion of the timbered area has been burned over. The principal streams in this basin are the Siletz, Alseya, Suislaw, Smiths, Umpqua, Coquille, Illinois, and Rogue rivers.

## SILETZ RIVER BASIN.

### SILETZ RIVER AT SILETZ, OREG.

This station was established November 25, 1905. It is located at Siletz, Oreg., about 1 mile above the ferry on the Siletz and Toledo stage road, 6 miles below the mouth of Rock Creek. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 252.

*Discharge measurements of Siletz River at Siletz, Oreg., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| November 26 | L. R. Allen | 157 | 394 | 2.15 | 1,170 |
| 1906. | | | | | |
| February 9 | L. R. Allen | 156 | 338 | 1.77 | 810 |
| March 29 | do | 157 | 370 | 2.03 | 1,030 |
| May 10 | do | 157 | 303 | [a]1.50 | 492 |
| July 23 | do | 151 | 231 | 1.23 | 309 |
| September 24 | I. E. Oakes | 155 | 289 | 1.60 | 592 |

[a] Possible backwater effect from small dam 75 feet below.

*Daily gage height, in feet, of Siletz River at Siletz, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.5 | 2.5 | 3.6 | 2.3 | 1.9 | 1.9 | 2.1 | 1.15 | 0.85 | 1.4 | 2.0 | 2.0 |
| 2 | 3.8 | 2.4 | 3.0 | 2.2 | 1.85 | 1.85 | 2.0 | 1.1 | .85 | 1.5 | 2.0 | 2.0 |
| 3 | 3.3 | 2.3 | 2.7 | 2.1 | 1.8 | 1.9 | 1.85 | 1.1 | .85 | 1.8 | 2.2 | 2.0 |
| 4 | 3.0 | 2.2 | 2.9 | 2.0 | 1.75 | 2.3 | 1.8 | 1.1 | .85 | 1.7 | 3.0 | 2.7 |
| 5 | 2.9 | 2.1 | 2.9 | 1.95 | 1.7 | 2.6 | 1.75 | 1.1 | .85 | 1.6 | 3.4 | 2.9 |
| 6 | 2.8 | 2.0 | 2.9 | 1.9 | 1.65 | 2.7 | 1.65 | 1.1 | .85 | 1.6 | 3.7 | 6.2 |
| 7 | 2.7 | 1.9 | 2.7 | 1.8 | 1.6 | 2.65 | 1.6 | 1.05 | .85 | 1.5 | 10.74 | 4.2 |
| 8 | 2.9 | 1.8 | 2.6 | 1.75 | 1.6 | 2.6 | 1.55 | 1.05 | .95 | 1.5 | 12.5 | 4.0 |
| 9 | 2.9 | 1.8 | 2.5 | 2.2 | 1.55 | 2.55 | 1.5 | 1.05 | .95 | 1.45 | 7.1 | 3.7 |
| 10 | 2.8 | 1.7 | 2.4 | 2.0 | 1.55 | 2.6 | 1.5 | 1.05 | .9 | 1.6 | 9.1 | 3.5 |
| 11 | 3.0 | 1.7 | 2.3 | 1.9 | 1.5 | 2.6 | 1.45 | 1.0 | .9 | 2.0 | 6.3 | 3.5 |
| 12 | 3.6 | 1.6 | 2.1 | 1.85 | 1.5 | 2.7 | 1.4 | 1.0 | .95 | 1.9 | 7.0 | 3.1 |
| 13 | 5.8 | 1.6 | 2.1 | 1.8 | 1.5 | 3.35 | 1.4 | 1.0 | 1.6 | 1.85 | 8.4 | 3.0 |
| 14 | 4.8 | 1.5 | 2.0 | 1.75 | 2.0 | 3.1 | 1.4 | 1.0 | 2.0 | 1.85 | 13.5 | 2.8 |
| 15 | 4.2 | 1.5 | 1.9 | 1.7 | 2.4 | 3.05 | 1.35 | 1.0 | 1.95 | 2.65 | 16.6 | 3.0 |
| 16 | 5.0 | 1.8 | 1.8 | 1.7 | 2.65 | 4.1 | 1.35 | 1.0 | 1.5 | 4.0 | 9.9 | 4.0 |
| 17 | 5.8 | 2.8 | 1.8 | 1.65 | 2.4 | 3.55 | 1.3 | .95 | 1.35 | 3.9 | 9.7 | 3.7 |
| 18 | 5.6 | 6.6 | 1.8 | 1.6 | 2.3 | 3.1 | 1.3 | .95 | 1.25 | 3.6 | 7.6 | 3.5 |
| 19 | 4.8 | 6.05 | 1.8 | 1.6 | 2.2 | 2.8 | 1.3 | .95 | 1.15 | 3.1 | 5.5 | 4.1 |
| 20 | 4.0 | 7.6 | 1.9 | 1.55 | 2.2 | 2.6 | 1.3 | .95 | 1.15 | 2.7 | 4.4 | 11.5 |
| 21 | 3.5 | 7.9 | 2.1 | 1.5 | 2.3 | 2.4 | 1.25 | .95 | 1.1 | 2.6 | 4.1 | 12.9 |
| 22 | 3.8 | 6.9 | 2.1 | 1.5 | 2.2 | 2.25 | 1.25 | .95 | 1.1 | 2.4 | 3.7 | 7.0 |
| 23 | 6.2 | 5.8 | 2.3 | 1.5 | 2.1 | 2.1 | 1.25 | .9 | 1.4 | 2.25 | 3.5 | 5.1 |
| 24 | 8.1 | 6.4 | 2.4 | 2.35 | 2.0 | 2.0 | 1.25 | .9 | 1.6 | 2.1 | 3.2 | 4.0 |
| 25 | 5.7 | 6.7 | 2.3 | 2.15 | 2.05 | 1.95 | 1.2 | .9 | 1.6 | 2.5 | 2.9 | 3.8 |
| 26 | 4.4 | 6.4 | 2.2 | 2.2 | 2.3 | 1.9 | 1.2 | .9 | 1.5 | 3.3 | 2.7 | 3.6 |
| 27 | 3.7 | 6.4 | 2.2 | 2.2 | 2.25 | 1.8 | 1.2 | .9 | 1.5 | 3.0 | 2.5 | 3.45 |
| 28 | 3.2 | 4.7 | 2.1 | 2.2 | 2.2 | 1.8 | 1.2 | .9 | 1.4 | 2.7 | 2.4 | 3.15 |
| 29 | 2.9 | ..... | 2.0 | 2.1 | 2.1 | 2.2 | 1.2 | .9 | 1.4 | 2.55 | 2.3 | 3.0 |
| 30 | 2.6 | ..... | 2.1 | 2.0 | 2.05 | 2.4 | 1.15 | .9 | 1.4 | 2.4 | 2.1 | 3.0 |
| 31 | 2.6 | ..... | 2.3 | ..... | 2.0 | ..... | 1.15 | .85 | ..... | 2.2 | ..... | 2.9 |

*Rating table for Siletz River at Siletz, Oreg., for 1906.*

| Gage height. | Discharge | Gage height. | Discharge | Gage height. | Discharge. | Gage height. | Discharge | Gage height. | Discharge |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.85 | 130 | 1.40 | 425 | 2.00 | 990 | 2.60 | 1,790 | 3.40 | 3,070 |
| 0.90 | 150 | 1.50 | 500 | 2.10 | 1,110 | 2.70 | 1,940 | 3.60 | 3,410 |
| 1.00 | 195 | 1.60 | 580 | 2.20 | 1,230 | 2.80 | 2,090 | 3.80 | 3,770 |
| 1.10 | 245 | 1.70 | 670 | 2.30 | 1,360 | 2.90 | 2,250 | 4.00 | 4,130 |
| 1.20 | 300 | 1.80 | 770 | 2.40 | 1,500 | 3.00 | 2,410 | | |
| 1.30 | 360 | 1.90 | 880 | 2.50 | 1,640 | 3.20 | 2,730 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 5 discharge measurements made during 1905–6 and is well defined between gage heights 1.2 feet and 2.2 feet.

*Monthly discharge of Siletz River at Siletz, Oreg., for 1906.*

[Drainage area, 220 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| March | 3,410 | 770 | 1,430 | 87,900 | 6.50 | 7.49 |
| April | 1,430 | 500 | 899 | 53,500 | 4.09 | 4.56 |
| May | 1,860 | 500 | 990 | 60,900 | 4.50 | 5.19 |
| June | 4,310 | 770 | 1,700 | 101,000 | 7.73 | 8.62 |
| July | 1,110 | 272 | 467 | 28,700 | 2.12 | 2.44 |
| August | 272 | 130 | 191 | 11,700 | .868 | 1.00 |
| September | 990 | 130 | 345 | 20,500 | 1.57 | 1.75 |
| October | 4,130 | 425 | 1,480 | 91,000 | 6.73 | 7.76 |
| November 1–7 | 3,590 | 990 | 1,750 | 24,300 | 7.95 | 2.07 |
| The period | | | | 480,000 | | |

NOTE.—The above estimates are provisional and subject to revision when more data are available. Values are rated as follows: April, May, and July, excellent; March, June, and August to November, good.

## UMPQUA RIVER DRAINAGE BASIN.

### UMPQUA RIVER AT ELKTON, OREG.

This station was established October 18, 1905, by J. G. Kelley, of Portland, Oreg., by whom it is maintained and the results furnished to the Geological Survey. It is located at Smiths Ferry, 4 miles above Elkton.

The gage is 100 feet above the ferry, on the left bank. It is an inclined staff fastened to bed rock. The gage datum is low water.

The following measurement was made August 11, 1906:

Width, 365 feet; area, 1,560 square feet; gage height, 0.07 foot; discharge, 1,340 second-feet.

*Daily gage height, in feet, of Umpqua River near Elkton, Oreg., for 1905–6.*

1905.

| Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 0.08 | 2.88 | 12 | ..... | 0.00 | 1.67 | 23 | .08 | .62 | 2.54 |
| 2 | ..... | .00 | 2.38 | 13 | ..... | .00 | 1.38 | 24 | .08 | .42 | 2.12 |
| 3 | ..... | .00 | 2.00 | 14 | ..... | .00 | 1.21 | 25 | .17 | .29 | 1.42 |
| 4 | ..... | .00 | 2.33 | 15 | ..... | .00 | 1.12 | 26 | .17 | .25 | 1.75 |
| 5 | ..... | .00 | 2.42 | 16 | ..... | .00 | 1.05 | 27 | .67 | .25 | 6.00 |
| 6 | ..... | .00 | 2.67 | 17 | ..... | .00 | .08 | 28 | .71 | 1.42 | 5.71 |
| 7 | ..... | .00 | 3.12 | 18 | 0.08 | .00 | 1.21 | 29 | .58 | 1.29 | 4.46 |
| 8 | ..... | .00 | 3.08 | 19 | .75 | .00 | 1.42 | 30 | .58 | 1.88 | 4.08 |
| 9 | ..... | .00 | 2.88 | 20 | .50 | .50 | 2.33 | 31 | .38 | ..... | 8.29 |
| 10 | ..... | .00 | 2.38 | 21 | .42 | 1.62 | 4.29 | | | | |
| 11 | ..... | .00 | 1.96 | 22 | 0.25 | 1.21 | 3.29 | | | | |

*Daily gage height, in feet, of Umpqua River near Elkton, Oreg., for 1905–6*—Continued.

1906.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.08 | 5.50 | 7.50 | 7.33 | 3.58 | 6.29 | 1.75 | 0.25 | 0.00 | 0.00 | 0.00 | 1.38 |
| 2 | 6.08 | 5.00 | 6.17 | 6.58 | 3.29 | 5.46 | 1.75 | .25 | .00 | .00 | .00 | 1.29 |
| 3 | 3.38 | 4.42 | 6.05 | 5.71 | 3.12 | 4.88 | 1.67 | .17 | .00 | .00 | .00 | 1.12 |
| 4 | 3.46 | 4.50 | 5.75 | 5.29 | 3.00 | 4.88 | 1.50 | .17 | .00 | .00 | .00 | 1.00 |
| 5 | 3.46 | 4.12 | 5.75 | 5.29 | 3.00 | 4.83 | 1.38 | .17 | .00 | .00 | .25 | 1.00 |
| 6 | 3.38 | 3.79 | 5.05 | 4.62 | 3.05 | 4.58 | 1.33 | .17 | .00 | .00 | .12 | 1.05 |
| 7 | 3.50 | 3.54 | 5.25 | 4.33 | 2.96 | 4.79 | 1.17 | .17 | .00 | .00 | 1.50 | 1.42 |
| 8 | 3.50 | 3.29 | 5.25 | 4.17 | 2.75 | 4.88 | 1.00 | .17 | .00 | .00 | 3.75 | 3.08 |
| 9 | 4.29 | 3.17 | 5.21 | 4.05 | 2.75 | 4.83 | 1.00 | .17 | .00 | .00 | 3.75 | 5.21 |
| 10 | 6.88 | 3.05 | 5.12 | 4.17 | 2.58 | 4.83 | .88 | .17 | .00 | .00 | 3.12 | 5.58 |
| 11 | 5.62 | 2.96 | 5.00 | 3.88 | 2.75 | 5.38 | .75 | .17 | .00 | .00 | 2.25 | 5.75 |
| 12 | 5.29 | 2.79 | 5.00 | 3.54 | 2.71 | 4.75 | .75 | .17 | .00 | .08 | 2.21 | 5.21 |
| 13 | 9.88 | 2.62 | 5.00 | 3.21 | 2.58 | 4.50 | .75 | .17 | .00 | .12 | 1.96 | 4.62 |
| 14 | 8.88 | 2.50 | 5.00 | 3.12 | 2.46 | 4.08 | .75 | .08 | .29 | .08 | 2.33 | 3.88 |
| 15 | 8.17 | 2.62 | 4.17 | 3.00 | 2.54 | 4.25 | .75 | .08 | 1.17 | .12 | 2.92 | 3.54 |
| 16 | 13.79 | 3.08 | 3.12 | 3.00 | 4.12 | 4.42 | .62 | .08 | 1.00 | .21 | 6.33 | 5.62 |
| 17 | 18.33 | 3.25 | 3.00 | 3.00 | 3.96 | 4.50 | .54 | .08 | .75 | .29 | 5.50 | 6.33 |
| 18 | 10.42 | 3.67 | 3.00 | 2.96 | 3.58 | 3.96 | .50 | .00 | .54 | 1.21 | 7.17 | 4.75 |
| 19 | 8.46 | 6.88 | 3.00 | 2.67 | 3.38 | 3.62 | .50 | .00 | .46 | 1.12 | 5.83 | 4.67 |
| 20 | 6.79 | 9.05 | 3.00 | 2.67 | 3.08 | 3.29 | .50 | .00 | .42 | 1.00 | 4.50 | 6.05 |
| 21 | 5.88 | 15.38 | 3.50 | 2.75 | 2.96 | 3.00 | .46 | .00 | .33 | .67 | 4.00 | 6.67 |
| 22 | 5.21 | 13.08 | 4.17 | 2.88 | 3.46 | 2.92 | .42 | .00 | .25 | .38 | 4.58 | 5.42 |
| 23 | 5.05 | 11.62 | 4.50 | 3.08 | 4.46 | 2.67 | .42 | .00 | .12 | .29 | 4.58 | 4.79 |
| 24 | 8.62 | 11.33 | 4.29 | 3.08 | 4.21 | 2.42 | .33 | .00 | .08 | .00 | 3.50 | 4.42 |
| 25 | 8.29 | 11.38 | 4.17 | 3.08 | 3.46 | 2.25 | .25 | .00 | .17 | .00 | 3.05 | 5.21 |
| 26 | 7.58 | 9.75 | 4.29 | 3.17 | 3.75 | 2.17 | .25 | .00 | .17 | .00 | 2.67 | 8.21 |
| 27 | 6.62 | 10.88 | 4.46 | 3.33 | 3.88 | 2.00 | .25 | .00 | .05 | .00 | 2.29 | 8.21 |
| 28 | 5.83 | 8.62 | 4.12 | 3.75 | 4.58 | 2.00 | .25 | .00 | .00 | .00 | 2.00 | 6.75 |
| 29 | 5.38 | ..... | 3.96 | 4.00 | 13.21 | 2.00 | .25 | .00 | .00 | .00 | 1.88 | 5.33 |
| 30 | 4.54 | ..... | 3.75 | 3.88 | 10.25 | 1.96 | .25 | .00 | .00 | .00 | 9.67 | 4.79 |
| 31 | 5.42 | ..... | 3.75 | ..... | 8.50 | ..... | .25 | .00 | ..... | .00 | ..... | 5.62 |

## NORTH FORK OF UMPQUA RIVER NEAR OAKCREEK, OREG.

This station was established September 6, 1905. It is located 3 miles west of Oakcreek, Oreg., 1¼ miles above J. R. Dixon's farmhouse, about 10 miles below the mouth of East Fork of North Fork of Umpqua River. The conditions at the station and the bench marks are described in Water-Supply Paper No. 177, page 251.

*Discharge measurements of North Fork of Umpqua River near Oakcreek, Oreg., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| September 6 | L. R. Allen | 215 | 457 | 1.35 | 886 |
| October 19 | do | 222 | 580 | 2.10 | 1,420 |
| December 27 | do | 279 | 1,450 | 5.35 | 7,110 |
| 1906. | | | | | |
| January 31 | L. R. Allen | 280 | 1,480 | 5.56 | 7,370 |
| March 20 | do | 249 | 847 | 3.23 | 2,780 |
| May 1 | do | 268 | 1,090 | 4.06 | 4,340 |
| May 30 | do | 284 | 1,800 | 6.74 | 10,200 |
| July 14 | do | 213 | 611 | 2.23 | 1,600 |
| August 10 | do | 190 | 508 | 1.73 | 1,120 |
| September 13 | do | 208 | 604 | 2.30 | 1,610 |

*Daily gage height, in feet, of North Fork of Umpqua River near Oakcreek, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.6 | 5.2 | 5.3 | 5.5 | 4.05 | 5.0 | 2.9 | 1.8 | 1.5 | 1.5 | 1.5 | 2.4 |
| 2 | 3.2 | 5.0 | 4.75 | 5.5 | 3.9 | 4.7 | 2.8 | 1.8 | 1.5 | 1.5 | 1.55 | 2.35 |
| 3 | 3.1 | 4.7 | 4.6 | 5.1 | 3.9 | 4.5 | 2.8 | 1.8 | 1.5 | 1.55 | 1.6 | 2.3 |
| 4 | 3.4 | 4.3 | 4.4 | 4.6 | 3.95 | 4.45 | 2.6 | 1.8 | 1.5 | 1.6 | 1.8 | 2.3 |
| 5 | 3.7 | 4.15 | 4.3 | 4.4 | 3.8 | 4.3 | 2.6 | 1.8 | 1.5 | 1.55 | 2.8 | 2.45 |
| 6 | 3.7 | 4.1 | 4.2 | 4.2 | 3.7 | 4.5 | 2.6 | 1.8 | 1.5 | 1.5 | 2.25 | 2.5 |
| 7 | 3.7 | 4.1 | 4.9 | 4.0 | 3.65 | 4.95 | 2.5 | 1.75 | 1.5 | 1.5 | 6.25 | 4.5 |
| 8 | 3.8 | 4.1 | 5.0 | 3.8 | 3.6 | 5.2 | 2.45 | 1.75 | 1.6 | 1.45 | 4.35 | 4.55 |
| 9 | 7.3 | 3.7 | 5.0 | 4.4 | 3.65 | 5.5 | 2.4 | 1.7 | 1.7 | 1.45 | 3.75 | 4.7 |
| 10 | 5.2 | 3.6 | 4.75 | 4.4 | 3.75 | 5.05 | 2.35 | 1.7 | 1.6 | 1.45 | 3.3 | 4.4 |
| 11 | 5.4 | 3.5 | 4.3 | 3.85 | 3.7 | 5.5 | 2.35 | 1.7 | 1.5 | 1.5 | 3.3 | 4.2 |
| 12 | 5.55 | 3.4 | 4.15 | 3.65 | 3.55 | 4.5 | 2.3 | 1.7 | 1.65 | 1.8 | 2.8 | 4.2 |
| 13 | 6.2 | 3.3 | 3.7 | 3.55 | 3.5 | 4.5 | 2.25 | 1.7 | 2.4 | 1.7 | 3.8 | 3.7 |
| 14 | 6.1 | 3.3 | 3.5 | 3.55 | 3.5 | 4.3 | 2.2 | 1.65 | 2.3 | 1.75 | 4.1 | 3.55 |
| 15 | 5.4 | 3.7 | 3.25 | 3.65 | 4.1 | 4.4 | 2.2 | 1.65 | 2.5 | 1.65 | 7.75 | 4.35 |
| 16 | 12.5 | 3.6 | 3.25 | 3.7 | 4.0 | 4.3 | 2.25 | 1.65 | 1.95 | 2.1 | 5.75 | 6.15 |
| 17 | 7.0 | 3.85 | 3.0 | 3.6 | 3.8 | 4.5 | 2.15 | 1.65 | 1.75 | 3.0 | 7.1 | 5.0 |
| 18 | 6.7 | 4.6 | 3.15 | 3.5 | 3.6 | 4.1 | 2.1 | 1.6 | 1.65 | 2.9 | 6.1 | 4.4 |
| 19 | 6.3 | 6.75 | 3.1 | 3.5 | 3.55 | 3.95 | 2.1 | 1.6 | 1.5 | 2.9 | 4.6 | 4.4 |
| 20 | 4.3 | 7.3 | 4.8 | 3.75 | 3.95 | 3.8 | 2.05 | 1.6 | 1.55 | 2.9 | 4.1 | 6.15 |
| 21 | 4.0 | 7.5 | 4.4 | 3.9 | 4.5 | 3.6 | 1.9 | 1.6 | 1.55 | 1.85 | 4.9 | 6.9 |
| 22 | 8.95 | 6.95 | 4.15 | 3.95 | 4.9 | 3.3 | 2.0 | 1.6 | 1.55 | 1.85 | 4.4 | 5.7 |
| 23 | 5.6 | 6.55 | 3.8 | 3.95 | 4.6 | 3.0 | 1.95 | 1.6 | 1.6 | 1.85 | 3.95 | 4.95 |
| 24 | 7.4 | 6.95 | 4.3 | 3.7 | 4.8 | 3.3 | 1.95 | 1.55 | 1.8 | 1.7 | 3.6 | 5.2 |
| 25 | 6.7 | 6.4 | 4.2 | 3.85 | 4.0 | 3.2 | 1.95 | 1.55 | 1.6 | 1.65 | 3.3 | 6.85 |
| 26 | 6.06 | 6.4 | 4.2 | 4.05 | 4.0 | 3.1 | 1.9 | 1.55 | 1.6 | 1.6 | 3.0 | 7.4 |
| 27 | 5.4 | 7.25 | 4.1 | 4.2 | 5.8 | 3.1 | 1.9 | 1.5 | 1.55 | 1.75 | 2.8 | 5.9 |
| 28 | 5.1 | 7.0 | 3.9 | 4.45 | 7.5 | 3.05 | 1.9 | 1.5 | 1.55 | 1.65 | 2.7 | 5.0 |
| 29 | 4.7 | ..... | 3.7 | 4.3 | 7.9 | 3.0 | 1.9 | 1.5 | 1.5 | 1.6 | 2.6 | 4.9 |
| 30 | 5.2 | ..... | 3.9 | 4.2 | 6.75 | 2.9 | 1.9 | 1.5 | 1.5 | 1.65 | 2.5 | 4.8 |
| 31 | 5.2 | ..... | 5.9 | ..... | 5.6 | ..... | 1.85 | 1.5 | ..... | 1.6 | ..... | 4.8 |

*Rating table for North Fork of Umpqua River near Oakcreek, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.30 | 860 | 2.50 | 1,860 | 3.70 | 3,580 | 4.90 | 5,930 | 7.20 | 11,340 |
| 1.40 | 920 | 2.60 | 1,980 | 3.80 | 3,760 | 5.00 | 6,150 | 7.40 | 11,860 |
| 1.50 | 985 | 2.70 | 2,100 | 3.90 | 3,940 | 5.20 | 6,590 | 7.60 | 12,390 |
| 1.60 | 1,055 | 2.80 | 2,230 | 4.00 | 4,130 | 5.40 | 7,040 | 7.80 | 12,930 |
| 1.70 | 1,130 | 2.90 | 2,360 | 4.10 | 4,320 | 5.60 | 7,500 | 8.00 | 13,470 |
| 1.80 | 1,205 | 3.00 | 2,500 | 4.20 | 4,510 | 5.80 | 7,960 | 9.00 | 16,300 |
| 1.90 | 1,285 | 3.10 | 2,640 | 4.30 | 4,700 | 6.00 | 8,420 | 10.00 | 19,300 |
| 2.00 | 1,370 | 3.20 | 2,780 | 4.40 | 4,900 | 6.20 | 8,900 | 11.00 | 22,300 |
| 2.10 | 1,460 | 3.30 | 2,930 | 4.50 | 5,100 | 6.40 | 9,380 | 12.00 | 25,300 |
| 2.20 | 1,550 | 3.40 | 3,080 | 4.60 | 5,300 | 6.60 | 9,860 | | |
| 2.30 | 1,650 | 3.50 | 3,240 | 4.70 | 5,510 | 6.80 | 10,340 | | |
| 2.40 | 1,750 | 3.60 | 3,410 | 4.80 | 5,720 | 7.00 | 10,830 | | |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 10 discharge measurements made during 1905–6 and is well defined between gage heights 1.3 feet and 7.0 feet.

*Monthly discharge of North Fork of Umpqua River near Oakcreek, Oreg., for 1905–6.*

[Drainage area, 1,000 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| September 6–30 | 1,090 | 860 | 902 | 44,700 | 0.902 | 0.839 |
| October | 2,300 | 920 | 1,270 | 78,100 | 1.27 | 1.46 |
| November | 2,230 | 890 | 1,190 | 70,800 | 1.19 | 1.33 |
| December | 9,020 | 1,650 | 3,020 | 186,000 | 3.02 | 3.48 |
| The period | | | | 380,000 | | |
| 1906. | | | | | | |
| January | 26,800 | 2,640 | 7,600 | 467,000 | 7.60 | 8.76 |
| February | 12,100 | 2,930 | 6,490 | 360,000 | 6.49 | 6.76 |
| March | 8,190 | 2,500 | 4,570 | 281,000 | 4.57 | 5.27 |
| April | 7,270 | 3,240 | 4,340 | 258,000 | 4.34 | 4.84 |
| May | 13,200 | 3,240 | 5,000 | 307,000 | 5.00 | 5.76 |
| June | 7,270 | 2,360 | 4,470 | 266,000 | 4.47 | 4.99 |
| July | 2,360 | 1,240 | 1,600 | 98,400 | 1.60 | 1.84 |
| August | 1,200 | 985 | 1,090 | 67,000 | 1.09 | 1.26 |
| September | 1,860 | 985 | 1,120 | 66,600 | 1.12 | 1.25 |
| October | 2,500 | 952 | 1,260 | 77,500 | 1.26 | 1.45 |
| November | 12,800 | 985 | 4,120 | 245,000 | 4.12 | 4.60 |
| December | 11,900 | 1,650 | 5,500 | 338,000 | 5.50 | 6.34 |
| The year | 26,800 | 952 | 3,930 | 2,830,000 | 3.93 | 53.12 |

NOTE.—Values for 1905 and 1906 are excellent.

## SOUTH FORK OF UMPQUA RIVER NEAR BROCKWAY, OREG.

This station was established December 6, 1905, by L. R. Allen. It is located just below Winston's highway bridge, 3 miles east of Brockway, Oreg., and 3 miles below the mouth of Lookingglass Creek. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 250.

*Discharge measurements of South Fork of Umpqua River near Brockway, Oreg., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| December 28 | L. R. Allen | 302 | 1,620 | 4.16 | 3,000 |
| 1906. | | | | | |
| February 1 | L. R. Allen | 303 | 1,650 | 4.32 | 3,490 |
| March 21 | do | 299 | 1,440 | 3.60 | 2,390 |
| May 2 | do | 295 | 1,200 | 2.82 | 1,500 |
| May 29 | do | 320 | 3,130 | 8.77 | 14,800 |
| May 29 | do | 318 | 2,920 | 8.40 | 13,800 |
| July 13 | do | 283 | 688 | .95 | 442 |
| August 9 | do | 276 | 481 | .22 | 205 |
| September 14 | I. E. Oakes | 284 | 642 | .78 | 414 |

*Daily gage height, in feet, of South Fork of Umpqua River near Brockway, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.4 | 4.35 | 6.25 | 5.9 | 3.0 | 5.1 | 1.65 | 0.4 | 0.05 | 0.25 | 0.3 | 1.25 |
| 2 | 3.6 | 4.1 | 5.55 | 5.35 | 2.8 | 4.4 | 1.55 | .35 | .05 | .25 | .3 | 1.15 |
| 3 | 3.25 | 4.0 | 5.05 | 4.9 | 2.75 | 4.1 | 1.55 | .35 | .05 | .25 | .35 | 1.35 |
| 4 | 3.0 | 3.75 | 5.0 | 4.7 | 2.65 | 4.1 | 1.4 | .35 | .05 | .25 | .4 | 1.2 |
| 5 | 3.15 | 3.5 | 4.75 | 4.45 | 2.6 | 3.9 | 1.3 | .35 | .05 | .25 | 2.0 | 1.2 |
| 6 | 3.2 | 3.35 | 4.7 | 4.2 | 2.5 | 3.25 | 1.3 | .35 | .05 | .25 | 2.1 | 1.25 |
| 7 | 3.15 | 3.2 | 4.6 | 4.0 | 2.45 | 3.25 | 1.2 | .3 | .05 | .2 | 2.8 | 1.6 |
| 8 | 3.1 | 3.05 | 4.6 | 3.75 | 2.3 | 3.4 | 1.2 | .25 | .05 | .2 | 3.1 | 4.0 |
| 9 | 4.7 | 2.95 | 4.5 | 3.7 | 2.25 | 3.95 | 1.1 | .25 | .05 | .15 | 2.8 | 4.1 |
| 10 | 5.25 | 2.85 | 4.35 | 3.7 | 2.25 | 4.1 | 1.05 | .25 | .1 | .15 | 2.6 | 4.4 |
| 11 | 4.5 | 2.75 | 4.2 | 3.45 | 2.25 | 4.1 | 1.05 | .2 | .15 | .15 | 1.9 | 5.8 |
| 12 | 6.45 | 2.6 | 4.0 | 3.25 | 2.2 | 4.0 | 1.0 | .2 | .25 | .2 | 1.65 | 5.0 |
| 13 | 8.2 | 2.55 | 3.75 | 3.1 | 2.1 | 3.8 | .95 | .2 | .45 | .3 | 1.45 | 4.1 |
| 14 | 6.75 | 2.5 | 3.55 | 2.9 | 2.1 | 3.55 | .95 | .2 | .6 | .35 | 1.35 | 3.5 |
| 15 | 6.6 | 3.0 | 3.35 | 2.9 | 2.7 | 3.3 | .85 | .15 | .8 | .35 | 1.1 | 3.5 |
| 16 | 18.1 | 3.0 | 3.2 | 2.9 | 3.6 | 3.3 | .8 | .15 | .9 | .35 | 4.35 | 5.25 |
| 17 | 9.9 | 3.05 | 3.05 | 2.8 | 3.4 | 3.3 | .8 | .15 | .9 | .45 | 3.95 | 4.65 |
| 18 | 7.4 | 3.65 | 2.9 | 2.7 | 3.15 | 3.1 | .8 | .1 | .85 | 1.05 | 5.3 | 4.05 |
| 19 | 6.0 | 6.2 | 3.0 | 2.6 | 2.95 | 2.85 | .75 | .1 | .75 | 1.00 | 4.2 | 4.0 |
| 20 | 5.35 | 9.05 | 3.1 | 2.55 | 2.7 | 2.65 | .7 | .05 | .6 | .95 | 3.6 | 4.4 |
| 21 | 4.4 | 10.7 | 3.5 | 2.55 | 2.55 | 2.5 | .65 | .05 | .4 | .75 | 3.1 | 4.4 |
| 22 | 4.45 | 10.3 | 3.95 | 2.65 | 2.75 | 2.4 | .65 | .05 | .3 | .75 | 3.95 | 3.9 |
| 23 | 4.65 | 8.3 | 4.15 | 2.75 | 3.4 | 2.25 | .6 | .05 | .35 | .65 | 3.6 | 3.5 |
| 24 | 6.65 | 8.0 | 4.0 | 2.8 | 3.2 | 2.15 | .6 | .05 | .4 | .65 | 3.1 | 3.35 |
| 25 | 6.3 | 7.3 | 4.0 | 2.8 | 3.0 | 2.05 | .55 | .05 | .45 | .5 | 2.75 | 3.6 |
| 26 | 5.8 | 7.25 | 4.05 | 2.8 | 3.0 | 1.9 | .55 | .05 | .45 | .45 | 2.3 | 6.55 |
| 27 | 5.1 | 8.5 | 4.05 | 2.75 | 3.4 | 1.9 | .5 | .05 | .3 | .45 | 2.05 | 5.8 |
| 28 | 4.75 | 7.3 | 3.8 | 3.2 | 3.7 | 1.9 | .5 | .05 | .25 | .4 | 1.75 | 4.85 |
| 29 | 4.4 | ..... | 3.6 | 3.3 | 9.1 | 1.85 | .45 | .05 | .25 | .4 | 1.65 | 4.3 |
| 30 | 4.15 | ..... | 3.45 | 3.15 | 7.4 | 1.75 | .45 | .05 | .25 | .35 | 1.4 | 3 95 |
| 31 | 4.4 | ..... | 4.25 | ..... | 6.0 | ..... | .4 | .05 | ..... | .35 | ..... | 4.9 |

*Rating table for South Fork of Umpqua River near Brockway, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 0.00 | 160 | 1.20 | 544 | 2.40 | 1,210 | 4.20 | 3,210 | 9 00 | 15,600 |
| 0.10 | 182 | 1.30 | 585 | 2.50 | 1,280 | 4.40 | 3,540 | 10.00 | 18,760 |
| 0.20 | 206 | 1.40 | 627 | 2.60 | 1,360 | 4.60 | 3,890 | 11.00 | 21,980 |
| 0 30 | 232 | 1.50 | 670 | 2.70 | 1,440 | 4.80 | 4,260 | 12 00 | 25,280 |
| 0.40 | 260 | 1.60 | 715 | 2.80 | 1,520 | 5 00 | 4 650 | 13 00 | 28,600 |
| 0.50 | 290 | 1.70 | 765 | 2.90 | 1,610 | 5.20 | 5,060 | 14 00 | 32,000 |
| 0.60 | 321 | 1.80 | 820 | 3.00 | 1,700 | 5.40 | 5,500 | 15 00 | 35,400 |
| 0.70 | 354 | 1.90 | 880 | 3.20 | 1,900 | 5.60 | 5,960 | 16 00 | 38,900 |
| 0.80 | 389 | 2.00 | 940 | 3.40 | 2,110 | 5.80 | 6,440 | 17 00 | 42,400 |
| 0.90 | 426 | 2.10 | 1,005 | 3.60 | 2,340 | 6.00 | 6,940 | 18.00 | 46,000 |
| 1.00 | 465 | 2.20 | 1,070 | 3.80 | 2,610 | 7.00 | 9,610 | | |
| 1.10 | 504 | 2.30 | 1,140 | 4.00 | 2,900 | 8.00 | 12,530 | | |

NOTE.—The above table is applicable only to open-channel conditions. It is based on 9 discharge measurements made during 1905–6 and is well defined below gage height 9 feet.

*Monthly discharge of South Fork of Umpqua River near Brockway, Oreg., for 1905–6.*

[Drainage area, 1,800 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| December 6–31 | 7,190 | 484 | 1,480 | 76,300 | 0.822 | 0.795 |
| 1906. | | | | | | |
| January | 46,400 | 1,700 | 6,760 | 416,000 | 3.76 | 4.34 |
| February | 21,000 | 1,280 | 6,120 | 340,000 | 3.40 | 3.54 |
| March | 7,580 | 1,610 | 3,160 | 194,000 | 1.76 | 2.03 |
| April | 6,690 | 1,320 | 2,340 | 139,000 | 1.30 | 1.45 |
| May | 15,900 | 1,000 | 2,480 | 152,000 | 1.38 | 1.59 |
| June | 4,850 | 792 | 2,020 | 120,000 | 1.12 | 1.25 |
| July | 740 | 260 | 434 | 26,700 | 2.41 | .28 |
| August | 260 | 171 | 200 | 12,300 | .111 | .13 |
| September | 426 | 171 | 250 | 14,900 | .139 | .16 |
| October | 484 | 194 | 272 | 16,700 | .151 | .17 |
| November | 5,280 | 232 | 1,470 | 87,500 | .817 | .91 |
| December | 8,380 | 524 | 3,010 | 185,000 | 1.67 | 1.92 |
| The year | 46,400 | 171 | 2,380 | 1,700,000 | 1.50 | 17.77 |

NOTE.—Values for 1905 and 1906 are rated as excellent.

## ILLINOIS RIVER DRAINAGE BASIN.

### ROGUE RIVER NEAR TOLO, OREG.[a]

This station was established August 30, 1905. It is located at Gold Ray, Oreg., 1½ miles below Tolo post-office, just below the Condor Water and Power Company's dam and bridge, and a short distance below the mouth of Stewart Creek. The conditions at this station and the bench marks are described in Water-Supply Paper No. 177, page 249.

*Discharge measurements of Rogue River near Tolo, Oreg., in 1905–6.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1905. | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| August 30 | L. R. Allen | 180 | 1,010 | 1.10 | 1,310 |
| October 17 | do | 180 | 1,020 | 1.20 | 1,210 |
| December 26 | do | 184 | 1,100 | 1.57 | 1,510 |
| 1906. | | | | | |
| January 29 | L. R. Allen | 188 | 1,270 | 2.51 | 2,920 |
| March 19 | do | 190 | 1,230 | 2.33 | 2,670 |
| April 30 | do | 192 | 1,470 | 3.24 | 4,570 |
| May 31 | do | 200 | 1,500 | 3.72 | 5,360 |
| July 12 | do | 184 | 1,100 | 1.64 | 1,800 |
| September 12 | I. E. Oakes | 178 | 981 | 1.06 | 1,350 |

[a] Referred to in 1905 report as "Gold Ray."

*Daily gage height, in feet, of Rogue River near Tolo, Oreg., for 1906.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.5 | 2.65 | 3.6 | ..... | 3.1 | 3.8 | 2.1 | 1.6 | 1.05 | 1.1 | 1.2 | 1.45 |
| 2 | 1.38 | 2.6 | 3.15 | 3.7 | 3.2 | 3.7 | 2.5 | 1.6 | 1.05 | 1.1 | 1.2 | 1.5 |
| 3 | 1.4 | 2.55 | 2.9 | 3.5 | 3.1 | 3.6 | 2.5 | 1.5 | 1.05 | 1.1 | 1.3 | 1.4 |
| 4 | 1.48 | 2.4 | 2.85 | 3.3 | 3.2 | 3.6 | 2.5 | 1.5 | 1.1 | 1.1 | 1.55 | 1.4 |
| 5 | 1.45 | 2.35 | 2.75 | 3.3 | 3.3 | 3.4 | 2.6 | 1.3 | 1.1 | 1.1 | 1.7 | 1.4 |
| 6 | 1.4 | 2.3 | 2.75 | 3.4 | 3.2 | 3.3 | 2.5 | 1.3 | 1.1 | 1.1 | 1.75 | 1.55 |
| 7 | 1.4 | 2.25 | 2.9 | 3.4 | 3.2 | 3.3 | 2.4 | 1.3 | 1.1 | 1.1 | 2.0 | 1.7 |
| 8 | 1.5 | 2.2 | 2.95 | 3.3 | 3.1 | 3.2 | 2.4 | 1.3 | 1.1 | 1.1 | 1.95 | 2.75 |
| 9 | 1.7 | 2.18 | 3.0 | 3.4 | 3.2 | 3.7 | 2.4 | 1.2 | 1.1 | 1.1 | 1.8 | 2.15 |
| 10 | 2.05 | 2.1 | 3.0 | 3.2 | 3.4 | 3.5 | 2.3 | 1.3 | 1.1 | 1.1 | 1.65 | 2.1 |
| 11 | 1.9 | 2.1 | 3.1 | 3.0 | 3.3 | 3.3 | 2.4 | 1.2 | 1.1 | 1.1 | 1.35 | 2.05 |
| 12 | 2.25 | 2.05 | 3.15 | 3.0 | 3.1 | 3.3 | 2.3 | 1.2 | 1.1 | 1.1 | 1.3 | 2.1 |
| 13 | 3.2 | 2.0 | 3.0 | 2.9 | 2.9 | 3.2 | 2.2 | 1.25 | 1.2 | 1.1 | 1.35 | 2.2 |
| 14 | 2.78 | 1.95 | 3.0 | 3.0 | 3.0 | 3.1 | 2.2 | 1.3 | 1.4 | 1.1 | 1.4 | 2.0 |
| 15 | 2.65 | 2.3 | 2.8 | 2.9 | 3.2 | 2.9 | 2.3 | 1.2 | 1.5 | 1.2 | 1.45 | 2.2 |
| 16 | 11.4 | 2.25 | 2.7 | 3.1 | 2.9 | 3.0 | 2.3 | 1.25 | 1.45 | 1.35 | 2.1 | 2.7 |
| 17 | 4.4 | 2.25 | 2.6 | 2.9 | 3.0 | 2.9 | 2.2 | 1.2 | 1.25 | 1.5 | 2.15 | 2.25 |
| 18 | 4.0 | 2.82 | 2.5 | 2.9 | 2.8 | 2.8 | 2.2 | 1.2 | 1.2 | 1.5 | 2.05 | 2.15 |
| 19 | 3.5 | 4.5 | 2.4 | 3.0 | 2.7 | 2.8 | 2.1 | 1.2 | 1.2 | 1.35 | 1.7 | 2.2 |
| 20 | 2.8 | 4.4 | 2.5 | 3.2 | ..... | 2.75 | 2.1 | 1.2 | 1.2 | 1.2 | 1.5 | 2.45 |
| 21 | 2.4 | 4.7 | 2.8 | 3.4 | 2.7 | 2.7 | 2.2 | 1.2 | 1.2 | 1.2 | 1.65 | 2.4 |
| 22 | 2.25 | 4.5 | 3.1 | ..... | 3.0 | 2.6 | 2.1 | 1.2 | 1.15 | 1.2 | 1.7 | 2.2 |
| 23 | 3.75 | 4.4 | 2.8 | 3.5 | 2.9 | 2.5 | 2.0 | 1.2 | 1.1 | 1.2 | 1.55 | 2.25 |
| 24 | 3.85 | 4.0 | 2.7 | 3.3 | 2.7 | 2.4 | 2.0 | 1.2 | 1.1 | 1.25 | 1.4 | 2.4 |
| 25 | 3.7 | 3.7 | 3.0 | 3.4 | 2.6 | 2.3 | 2.0 | 1.2 | 1.1 | 1.3 | 1.4 | 3.5 |
| 26 | 3.25 | 3.8 | 3.5 | 3.0 | 2.7 | 2.35 | 1.9 | 1.2 | 1.1 | 1.35 | 1.35 | 4.75 |
| 27 | 2.95 | 4.6 | 3.1 | 3.2 | ..... | 2.4 | 1.9 | 1.2 | 1.1 | 1.3 | 1.4 | 3.4 |
| 28 | 2.75 | 3.9 | 3.0 | 3.3 | 3.8 | 2.3 | 1.7 | 1.2 | 1.1 | 1.2 | 1.35 | 2.95 |
| 29 | 2.55 | ..... | 2.8 | 3.2 | 4.7 | 2.3 | 1.8 | 1.2 | 1.1 | 1.2 | 1.35 | 2.95 |
| 30 | 2.5 | ..... | 2.9 | 3.1 | 4.4 | 2.2 | 1.7 | 1.05 | 1.1 | 1.2 | 1.35 | 3.15 |
| 31 | 2.7 | ..... | 5.1 | ..... | 3.9 | ..... | 1.7 | 1.1 | ..... | 1.2 | ..... | 2.9 |

*Rating table for Rogue River near Tolo, Oreg., for 1905–6.*

| Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1.00 | 1,200 | 2.00 | 2,160 | 3.00 | 3,830 | 4.00 | 6,000 | 6.00 | 11,320 |
| 1.10 | 1,270 | 2.10 | 2,300 | 3.10 | 4,030 | 4.20 | 6,480 | 6.20 | 11,900 |
| 1.20 | 1,340 | 2.20 | 2,450 | 3.20 | 4,230 | 4.40 | 6,980 | 6.40 | 12,480 |
| 1.30 | 1,420 | 2.30 | 2,600 | 3.30 | 4,440 | 4.60 | 7,490 | 6.60 | 13,060 |
| 1.40 | 1,500 | 2.40 | 2,760 | 3.40 | 4,650 | 4.80 | 8,010 | 6.80 | 13,660 |
| 1.50 | 1,590 | 2.50 | 2,930 | 3.50 | 4,870 | 5.00 | 8,540 | 7.00 | 14,260 |
| 1.60 | 1,690 | 2.60 | 3,100 | 3.60 | 5,090 | 5.20 | 9,080 | 8.00 | 17,280 |
| 1.70 | 1,800 | 2.70 | 3,280 | 3.70 | 5,310 | 5.40 | 9,620 | 9.00 | 20,500 |
| 1.80 | 1,910 | 2.80 | 3,460 | 3.80 | 5,540 | 5.60 | 10,180 | 10.00 | 23,850 |
| 1.90 | 2,030 | 2.90 | 3,640 | 3.90 | 5,770 | 5.80 | 10,740 | 11.00 | 27,300 |

NOTE.—The above table is applicable only for open-channel conditions. It is based on 8 discharge measurements made during 1905–6 and is fairly well defined below gage height 4 feet.

*Monthly discharge of Rogue River near Tolo, Oreg., for 1905–1906.*

[Drainage area, 2,020 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1905. | | | | | | |
| September | 1,690 | 1,240 | 1,300 | 77,400 | 0.644 | 0.718 |
| October | 1,690 | 1,300 | 1,390 | 85,500 | .688 | .793 |
| November | 1,590 | 1,340 | 1,370 | 81,500 | .678 | .756 |
| December | 1,930 | 1,320 | 1,490 | 91,600 | .738 | .851 |
| The period | | | | 336,000 | | |
| 1906. | | | | | | |
| January | 27,800 | 1,480 | 4,000 | 246,000 | 1.98 | 2.28 |
| February | 7,750 | 2,090 | 4,040 | 224,000 | 2.00 | 2.08 |
| March | 8,810 | 2,760 | 3,840 | 236,000 | 1.90 | 2.19 |
| April | 7,060 | 3,640 | 4,370 | 260,000 | 2.16 | 2.41 |
| May | 7,750 | 3,100 | 4,220 | 259,000 | 2.09 | 2.41 |
| June | 5,540 | 2,450 | 3,840 | 228,000 | 1.90 | 2.12 |
| July | 3,100 | 1,800 | 2,440 | 150,000 | 1.21 | 1.40 |
| August | 1,690 | 1,230 | 1,390 | 85,500 | .688 | .79 |
| September | 1,590 | 1,230 | 1,310 | 78,000 | .648 | .72 |
| October | 1,590 | 1,270 | 1,340 | 82,400 | .663 | .76 |
| November | 2,380 | 1,340 | 1,680 | 100,000 | .832 | .93 |
| December | 7,880 | 1,500 | 2,820 | 173,000 | 1.40 | 1.61 |
| The year | 27,800 | 1,230 | 2,940 | 2,120,000 | 1.46 | 19.70 |

NOTE.—Discharges have been interpolated for days when gage was not read. Values for 1905–1906 are rated good.

## ROGUE RIVER NEAR GALICE, OREG.

This station was established May 29, 1906. It is located at the ferry on the Mertin-Galice road in sec., 9, T. 35 S., R. 7 W. The gage is an inclined staff on the left bank.

Gage heights, discharge measurements, and monthly discharges have been furnished by Charles Gilman Hyde, University of California, Berkeley, Cal.

*Discharge measurements of Rogue River near Galice, Oreg., in 1906.*

| Date. | Hydrographer. | Gage height. | Discharge. |
|---|---|---|---|
| | | *Feet.* | *Sec.-ft.* |
| May 16 | C. G. Hyde | 6.5 | 4,170 |
| August 6 | do | 4.5 | 1,400 |

*Daily gage height of Rogue River at Galice, Oregon, for 1906.*

| Day. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| 1 | | 7.5 | 5.6 | 4.5 | 4.35 | 4.4 | 4.35 | 4.6 |
| 2 | | 7.4 | 5.5 | 4.5 | 4.35 | 4.4 | 4.4 | 4.6 |
| 3 | | 7.3 | 5.5 | 4.5 | 4.35 | 4.4 | 4.5 | 4.5 |
| 4 | | 7.6 | 5.4 | 4.5 | 4.35 | 4.4 | 4.6 | 4.5 |
| 5 | | 7.4 | 5.4 | 4.5 | 4.35 | 4.4 | 4.85 | 4.6 |
| 6 | | 7.1 | 5.3 | 4.5 | 4.35 | 4.35 | 4.75 | 5.3 |
| 7 | | 7.2 | 5.3 | 4.5 | 4.3 | 4.35 | 4.65 | 5.8 |
| 8 | | 7.1 | 5.2 | 4.5 | 4.25 | 4.35 | 5.8 | 6.3 |
| 9 | | 7.7 | 5.15 | 4.5 | 4.4 | 4.3 | 5.0 | 6.1 |
| 10 | | 7.5 | 5.05 | 4.4 | 4.5 | 4.35 | 4.8 | 6.0 |
| 11 | | 7.3 | 5.0 | 4.4 | 4.4 | 4.35 | 4.8 | 5.8 |
| 12 | | 7.5 | 5.0 | 4.4 | 4.35 | 4.35 | 4.8 | 5.6 |
| 13 | | 7.2 | 4.9 | 4.4 | 4.5 | 4.35 | 4.75 | 5.5 |
| 14 | | 7.0 | 4.9 | 4.4 | 4.7 | 4.35 | 4.75 | 5.4 |
| 15 | | 6.8 | 4.9 | 4.4 | 4.6 | 4.4 | 5.0 | 5.8 |
| 16 | | 7.2 | 4.9 | 4.4 | 4.5 | 4.4 | 5.85 | 6.8 |
| 17 | | 6.9 | 4.8 | 4.4 | 4.5 | 4.5 | 5.85 | 6.2 |
| 18 | | 6.7 | 4.8 | 4.4 | 4.5 | 4.5 | 5.8 | 5.7 |
| 19 | | 6.5 | 4.8 | 4.4 | 4.4 | 4.5 | 5.5 | 5.5 |
| 20 | | 6.4 | 4.7 | 4.4 | 4.4 | 4.5 | 5.0 | 5.7 |
| 21 | | 6.3 | 4.7 | 4.4 | 4.5 | 4.5 | 5.0 | 6.0 |
| 22 | | 6.2 | 4.7 | 4.4 | 4.5 | 4.5 | 5.2 | 5.7 |
| 23 | | 6.1 | 4.7 | 4.4 | 4.4 | 4.45 | 5.0 | 5.6 |
| 24 | | 6.1 | 4.7 | 4.4 | 4.4 | 4.45 | 5.0 | 5.6 |
| 25 | | 6.0 | 4.6 | 4.4 | 4.4 | 4.45 | 4.9 | 6.7 |
| 26 | | 5.9 | 4.6 | 4.4 | 4.4 | 4.4 | 4.9 | 9.8 |
| 27 | | 5.9 | 4.6 | 4.4 | 4.4 | 4.4 | 4.8 | 8.1 |
| 28 | | 5.8 | 4.5 | 4.4 | 4.4 | 4.4 | 4.7 | 7.0 |
| 29 | 9.0 | 5.7 | 4.5 | 4.4 | 4.3 | 4.35 | 4.7 | 6.8 |
| 30 | 8.6 | 5.6 | 4.5 | 4.4 | 4.3 | 4.35 | 4.6 | 7.5 |
| 31 | 8.5 | | 4.5 | 4.4 | | 4.35 | | 7.0 |

*Monthly discharge of Rogue River near Galice, Oreg., in 1906.*

| Month. | Discharge in second-feet. | | | Total in acre-feet. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| June | 6,250 | 2,700 | 4,700 | 280,000 |
| July | 2,700 | 1,400 | 1,800 | 111,000 |
| August | 1,400 | 1,350 | 1,360 | 83,600 |
| September | 1,600 | 1,225 | 1,350 | 80,300 |
| October | 1,400 | 1,300 | 1,350 | 83,000 |
| November | 3,125 | 1,300 | 1,850 | 110,000 |
| December | 9,950 | 1,400 | 3,350 | 206,000 |
| The period | | | | 954,000 |

## NEHALEM RIVER DRAINAGE BASIN.

### NEHALEM RIVER AT FISHHAWK, OREG.

This station is located at Fishhawk post-office, below the mouth of Fishhawk Creek. The bed of the stream is of clean sand, liable to shift. Measurements are made from a cable and car. The gage rod is a 2 by 8 inch timber in four sections. The bench mark is the top of three spikes driven in the upper side of a cedar stump about 50 feet above the cable on the left bank; elevation, 23.69 feet above the datum of the gage. No gage heights were observed during 1906.

*Discharge measurements of Nehalem River at Fishhawk, Oreg., in 1906.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| April 18 | L. R. Allen | 59 | 316 | 1.02 | 386 |
| April 19 | do | 59 | 203 | .93 | 364 |
| May 21 | do | 59 | 284 | .52 | 310 |
| August 1 | do | 55 | 179 | .24 | 102 |

## MISCELLANEOUS MEASUREMENTS.

The following miscellaneous measurements were made in North Pacific Ocean drainage in 1906:

*Miscellaneous measurements in North Pacific Ocean drainage in 1906.*

| Date. | Stream. | Locality. | Width. | Area of section. | Discharge. |
|---|---|---|---|---|---|
| | | | *Feet.* | *Sq. ft.* | *Sec.-ft.* |
| August 5 | Antelope Creek | Eagle Point | | | 0 |
| August 8 | Applegate Creek | Ruch | 41 | 88 | 110 |
| August 5 | Big Butte Creek | Sec. 14, T. 34 S., R. 1 E | 102 | 291 | 184 |
| August 6 | Condor Water and Power Co.'s canal. | Prospect, 200 feet below dam. | 14 | 36 | 74 |
| August 7 | Elk Creek | Sec. 31, T. 33 S., R. 1 W | 25 | 20 | 9.1 |
| August 5 | Little Butte Creek | Eagle Point | 36 | 42 | 48 |
| August 6 | Rogue River | Prospect, below dam | 53 | 289 | 445 |
| August 13 | Siuslaw River | Below Walton Creek, sec. 16, T. 18 S., R. 8 W. | 107 | 127 | 131 |
| August 7 | Trail Creek | Mouth | | | 0 |

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THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

OCTOBER, 1907.

O

Water-Supply Paper No. **215**

Series { A, Economic Geology, 96
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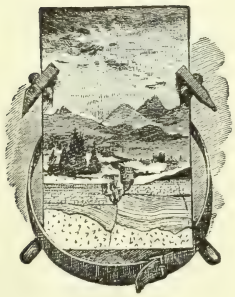
# GEOLOGY AND WATER RESOURCES

OF A PORTION OF THE

# MISSOURI RIVER VALLEY IN NORTHEASTERN NEBRASKA

BY

G. E. CONDRA



WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

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# GEOLOGY AND WATER RESOURCES OF A PORTION OF THE MISSOURI RIVER VALLEY IN NORTHEASTERN NEBRASKA.

By G. E. Condra.

## INTRODUCTION.

The region considered in this report lies in northeastern Nebraska, south of Missouri River, and extends about 150 miles east and west and approximately 29 miles north and south. The total area is over 4,100 square miles, comprising Dakota, Cedar, Knox, and Boyd counties and the northern part of Holt County, as shown in Pl. I.

The eastern part of the area was settled long ago, and the western counties are now rapidly filling up. The entire region has a fertile soil, and there is sufficient rainfall to insure crops in most seasons, especially where careful cultivation is practiced. Very little irrigation is needed, and a few short ditches constructed during exceptionally dry years are not used at present. In 1903 no irrigation whatever was employed.

Stock raising is carried on extensively where the land is not farmed. There is an abundance of ground water throughout most of the area, yet at places in Boyd, Knox, and Holt counties there is difficulty in obtaining a sufficient supply of good well water for stock and domestic purposes. On this account considerable space is given in this report to ground water and shallow wells in those counties.

Many springs, some of them of good volume, are found in every county. Artesian wells are obtained on the Missouri bottom and adjacent lowlands from eastern Boyd to the northeastern part of Dixon County.

This report is a result of studies made in the field during the summer of 1903, under the direction of N. H. Darton. There was found to be much local interest in cement rock, coal, and the water conditions. Special trips were made into Dixon and Dakota counties with Prof. J. E. Todd, who has furnished important suggestions as to the geology and has supplied several sections. It was found necessary to determine the broader structural and stratigraphic relations of the Cretaceous formations, and, in order to do this, observations were continued into Iowa and South Dakota.

Only about 250 square miles of the area have been topographically surveyed and these are included in the Elk Point quadrangle, which extends from South Dakota into Dixon and Dakota counties. Outside of that area altitudes were obtained from railroad levels and by the use of an aneroid barometer.

## TOPOGRAPHY.

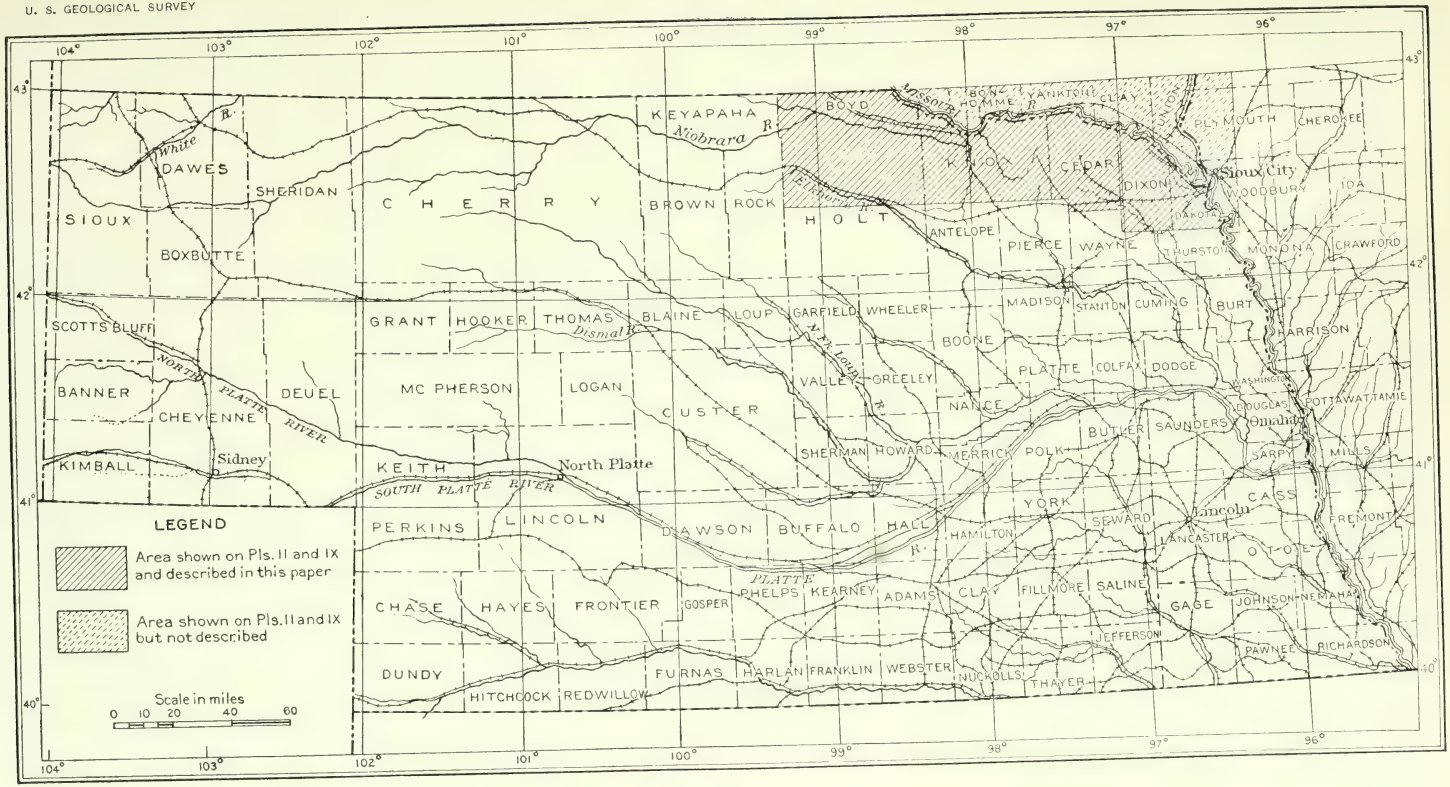
The principal topographic features of the region are the result of the erosive action of streams, but glacial action has modified the surface in some districts by changing the preglacial drainage and adding deposits of gravel, sand, bowlders, and clay, while the wind has modified certain sandy surfaces into small areas of dunes. The altitude varies from over 2,100 feet on the table-lands of western Holt and Boyd counties to about 1,100 feet on the lowlands of Dakota County. The Missouri River, which is the principal stream, has eroded a trough, usually with steep slopes, to an average depth of 500 to 600 feet below the general upland level. The entire area slopes gradually downward from west to east, and more steeply northward from the high divides toward Missouri River. While most of the area slopes and drains northward toward that river, the drainage of small portions of Holt, Knox, Cedar, Dixon, and Dakota counties flows southeastward and reaches the river farther south.

## DESCRIPTIVE GEOLOGY.

### STRATIGRAPHY.

Study of the local geology of a region affords information concerning the soil, aids in drilling artesian wells by indicating the thickness and character of the formations through which the drill must pass, and is a guide to many natural resources which may be advantageously developed.

The formations in this area are all of sedimentary origin and belong to the Cretaceous, Tertiary, and Quaternary systems. The Cretaceous strata, which are the lowest exposed, consist of beds wide in extent and nearly horizontal in position or with a slight dip to the west. They are composed of clay, chalk, limestone, and sandstone, which were for the greater part marine accumulations of mud, minute calcareous shells, and sand. These formations outcrop extensively along Missouri River and other streams, as shown in Pl. II (in pocket), and by well records their relations at other places are known. The total thickness of the Cretaceous beds in the western part of Boyd County is thought to be about 1,400 feet. From records of deep borings at Ponca and Sioux City it is known that the Carboniferous limestones also underlie the region, beginning at a depth of about 545 feet at Ponca, Nebr., and 335 feet at Sioux City, Iowa.




SKETCH MAP OF NEBRASKA.

The following sections represent the succession at certain typical localities:

*Section below the mouth of Aowa Creek, Dixon County, Nebr.*

| | Feet. |
|---|---|
| Loess, extends 98 feet higher in slope; exposed | 7–36 |
| Glacial till | 22 |
| Greenhorn limestone: | |
| Limestone, slabby, with many remains of *Inoceramus labiatus* | 5½ |
| Clay, dark, sandy, with some chalk | 1 |
| Limestone, slabby, containing *Inocerami* | 4 |
| Limestone, bluish, chalky, weathers to a light color resembling Niobrara chalk rock; contains some *Inocerami* | 9 |
| Graneros shale: | |
| Clay, bluish and somewhat chalky above, dark below, contains iron pyrites concretions, and sulphate of iron as a powder | 49½ |
| Clay, dark, at places carbonaceous above, usually sandy, containing concretions of iron pyrites and marcasite and rosettes of selenite | 7 |
| Dakota sandstone: | |
| Sandstone, light to rusty color, porous, and soft; with root marks. Rusty iron concretions occur near the center and base. The beds thicken and dip westward | 7–10 |
| Clay, dark, contains irregular streaks of light-colored sand | 2½ |
| Sandstone, nodular, contains rusty iron, limy at places | ¾ |
| Shale and nodules, dark, very sandy near ravine | 1 |
| Sandstone, with layers of concretionary iron between beds | 4½ |
| Sandstone, rusty and dark, varying from sandstone to shale | 5½–6 |
| Sandstone, rusty, porous at 1,120 feet above sea level | |

The beds show a steeper westward inclination near the mouth of Aowa Creek, beyond which they appear to rise again for a short distance.

*Combined section from Vermilion Ferry to the Dixon-Cedar county line.*

| No. | Feet. |
|---|---|
| 7. Loess; thick on higher slopes. | |
| 6. Glacial drift; usually covered by loess | 0–3 |
| 5. Niobrara chalk rock, light color, soft, rises in hills above, exposed in three banks | 1–5 |
| 4. Clay, dark, with some selenite crystals, sandy at places | 13 |
| 3. Sandstone and clay, varies from sandstone to plastic clay. Beds carbonaceous at places | 8 |
| 2. Clay, bluish or dark, plastic, covered with many selenite crystals. Contains two zones of calcareous concretions, one 63–65 feet and the other 55 feet above the river. In one bank a thin bed of rusty sandstone is found 10 feet above the river | 73 |
| 1. Shale, dark blue, chalky, containing *Serpula*, large, flat *Inocerami*, *Ostrea congesta*, and *Prionocyclus*. Exposed above water | 3–4 |
| Altitude of top of No. 1, at ferry | 1,130 |
| Altitude of base of No. 5 | 1,224 |
| All below No. 5 are included in the Carlile shale of the Benton group. | |

On the eroded upper surface of the Cretaceous lie sheets of sand and clay of Tertiary age, which are thickest and most typically de-

veloped in the western parts of Boyd and Holt counties, and thin out in Knox and Cedar counties. The only portion of the Tertiary thus far identified here is the Arikaree formation and an unnamed formation of Pliocene age. A more careful examination of the western part of the region may possibly show the presence of outliers of the White River formation below the Arikaree.

Lying on the eroded surface of the Cretaceous and Tertiary formations, over wide areas, are the deposits of clay, sand, gravel, bowlders, loess, and alluvium of Quaternary age.

## STRUCTURE.

In outcrops in northeastern Nebraska the rocks usually appear to lie horizontal, but they have a slight general inclination to the west or west-northwest, which becomes very low for some distance above the mouth of Niobrara River. The principal structural features are shown on the cross sections Pl. III (in pocket). The westerly dip is indicated by the differences in altitude of the top of the Dakota sandstone, which slopes from a height of 40 feet above the river level, or altitude of 1,160 feet, at Sioux City to a depth of 500 feet, or altitude of about 720 feet, at Niobrara. This difference of 440 feet in 80 miles indicates an average dip of $5\frac{1}{2}$ feet to the mile. The dip from Sioux City to Ponca, however, is slight, making the average dip from Ponca to Niobrara about 7 feet to the mile. At Lynch, 23 miles west of Niobrara, the altitude of the top of the formation is about 690 feet, which indicates a fall of only about 1 foot to the mile in that direction, while to the northwest, up the Missouri valley, there is a similar low dip.

## DESCRIPTION OF THE ROCKS.

### CRETACEOUS SYSTEM.

#### DAKOTA SANDSTONE.

The Dakota sandstone is of considerable economic importance, furnishing artesian water, brick clay, fair building stone in places, and small amounts of a poor grade of lignite coal.

It outcrops occasionally in bluffs in southeastern Dakota County, Nebr., at Sioux City, Iowa, and along Big Sioux River in Iowa. In Nebraska the formation outcrops at intervals from the high hills southeast of Homer to a point northeast of Ponca, where it passes beneath the river level. It extends far to the northwest and the southwest under later formations and comes to the surface in the Black Hills and the Rocky Mountains. According to well records, its upper surface lies at a depth of 360 feet at Aten, 600 feet at Santee, 500 feet at Niobrara, and 700 feet at Lynch.

The formation is penetrated by wells at Ponca, Nebr., and Sioux City, Iowa, where in each case the thickness is thought to be between

300 and 400 feet. In the Ponca well, 700 feet deep, the base of the formation appears to be at an altitude of about 755 feet, while its upper surface, exposed in bluffs east of the town, rises to 1,135 feet, indicating a thickness of 380 feet; but this estimate probably is somewhat too large.

According to Professor Todd the mouth of the Sioux City well is 38 feet below the outcrops of the sandstone, whose altitude is 1,122 feet, and, as the bottom of this sandstone, according to the well record, is at an altitude of 825 feet, the thickness is 335. It is thought, however, that the beds observed near the mouth of the well are not at the top of the formation and that some higher strata have been removed by erosion.

The Dakota formation is composed largely of thick deposits of coarse friable sandstone, light buff to rusty in color, with interbedded clay beds of different colors, mostly blue, gray, and yellow. One thick bed of clay north of Sioux City overlies the massive cross-bedded sandstone which outcrops along the river banks in that vicinity. Numerous iron-oxide concretions abound in the clay, as do also thin beds of sandstone merging into irregular, sandy iron-oxide deposits of variable thickness. Lignite, in thin irregular beds, occurs in the upper part of the formation, and also at lower levels near Jackson and Homer. Many well-preserved leaves are found which have been studied and described by various paleontologists.

The component beds of the Dakota formation in this region are not sufficiently continuous, extensive, nor distinctive to afford a basis for subdividing the formation into different horizons, yet in the outcrop area the following order has been observed, passing downward: (1) Porous sandstone with root marks, interstratified clays, and shale or lignite beds; (2) clay, thin sandstone, and concretionary ironstone beds; (3) massive, cross-bedded sandstone with thin beds of clay.

As the sandstones weather more slowly than the clay beds they often form bluffs (see Pl. IV, *A*), which extend as a more or less continuous escarpment from southeastern Dakota County to a point near Ponca. At cut banks along the river and near the mouths of a few ravines these bluffs form prominent points and buttresses. The topography varies somewhat, the massive sandstone giving sharp outlines and the clay more gradual slopes. Loess and Graneros clay often slide down over these outcrops, concealing the beds.

*Section of Dakota sandstone 5 miles southeast of Homer, Nebr.*

| | Feet. |
|---|---|
| Thin beds of sandstone and clay, colored by iron | 18 |
| Sandstone, massive, cross-bedded. These beds vary much in texture; within a few feet they may grade from sand into sandstone and even quartzite. The colors are light gray, rusty, and dark | 19 |

*Section of Dakota sandstone and overlying loess at the quarry just northwest of Homer, Nebr.*

| | Feet. |
|---|---|
| Loess at top of bluff | 12 |
| Clay, shaly and oxidized to a yellowish color | 2 |
| Sandstone, light colored, porous, massive, not cross-bedded | 7 |
| Clay, light colored, concretionary | 2 |
| Sandstone, much like No. 6 but with root marks in upper part | 10 |
| Clay, light colored, sandy, oxidized; yellowish at places, with hard layers of concretionary iron 1 to 12 inches thick | 28 |
| Clay, yellowish, with fewer iron concretions than in No. 3 | 5 |
| Sandstone, light colored to rusty, massive, cross-bedded, interstratified with thin layers of clay | 20 |

In the Ashford well just west of Homer, the lowest bed of the above section was not penetrated at a level fully 70 feet lower. This member of the Dakota formation rises high in the bluffs some 6 or 7 miles southeast of Homer.

*Section of Dakota sandstone and glacial clay in the quarry at Jackson, Dakota County, Nebr.*

| | Feet. |
|---|---|
| Glacial clay with some sand | 3 |
| Sandstone, rusty | ½–1 |
| Sandstone, light colored, loosely cemented | 2 |
| Sandstone, rusty to light colored, friable, in beds 2 to 8 inches thick with thin layers of light-colored clay between | 8 |
| Clay, sandy, light colored | ½ |
| Sandstone, light colored, friable | 1½ |
| Sandstone, clay or sand, varying; color rusty to light | 3 |

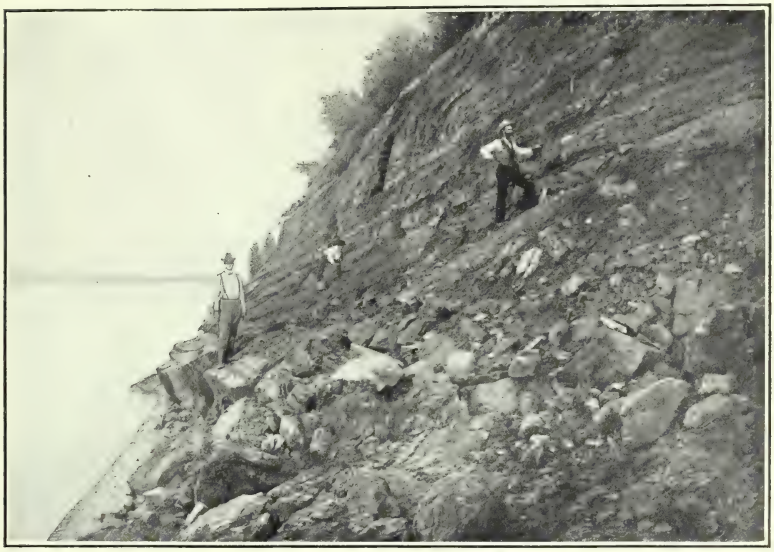
Parts of the stone in this quarry are used for building purposes. Several good specimens of leaves were found here. According to the report of the well drillers a thin bed of impure coal lies 30 feet below the lowest point in the quarry.

*Record of Mattison's well, N.E. ¼ S.W. ¼ sec. 20, T. 31 N., R. 6 E., southeast of Ionia, Nebr.*

| | Feet. |
|---|---|
| Shaly limestone | 0– 8 |
| Chalk | 8– 12 |
| Dark shale | 12– 45 |
| Blue clay | 45–105 |
| Soft sandstone | 105–277 |
| Sand and gravel | 277–302 |
| Clay or shale | 302–312 |
| Soft sandstone | 312–487 |
| Gravel | 487–517 |

### BENTON GROUP.

The Benton group lies between the Dakota and Niobrara formations and, as Mr. Darton has shown, is separable in this region into three distinct formations, which represent the Graneros shale, the Green-



*A*. DAKOTA SANDSTONE ON BANK OF MISSOURI RIVER BELOW MOUTH OF AOWA CREEK.

*B*. GREENHORN LIMESTONE ON GRANEROS SHALE NORTHEAST OF PONCA, NEBR.

horn limestone, and the Carlile formation of eastern Colorado and the Black Hills.

*Graneros shale.*—The best exposures of the Graneros shale are in river bluffs below the mouth of the Aowa Creek, above Ponca Landing, and at the Bigley Ravine, near Ponca. The shale lies on the Dakota sandstone and is overlain by the Greenhorn limestone. It occurs high in the slopes in Dakota County, and dips gradually to the northwest, its base reaching the level of the river about 3 miles north of Ponca. The thickness in Dixon County is from 50 to 60 feet, while in the Black Hills it varies from 800 to 900 feet. According to Mr. Burchard [a] it appears to thin out and disappear southeast of Homer, where the Greenhorn limestone lies very close to if not directly on the Dakota sandstone. It is composed principally of very dark gray to bluish-gray clay or soft shale which grades above and below into harder shale. The section at the mouth of Aowa Creek (p. 7) shows the usual relations.

*Greenhorn limestone.*—This medial member of the Benton group lies from 50 to 60 feet above the Dakota sandstone and is 18 to 20 feet thick, not including a few feet of shaly transition beds above and below. The principal rock is fossiliferous limestone with an admixture of clay and some sand. The upper beds are slabby, highly fossiliferous, and stained with iron, while the lower beds are more massive and chalky and contain a smaller number of large fossils. The formation is characterized by very numerous casts of *Inoceramus labiatus* (see Pl. VI). This limestone was traced from high in the hills of southeastern Dakota County to the river level in the Ionia section northeast of Newcastle.

Pl. IV, *B* shows a characteristic outcrop of this limestone. These beds weather out like chalk and were formerly mistaken for the Niobrara chalk rock, which, however, occurs at a higher level farther west.

*Section of Greenhorn limestone and associated beds in cut bank and slide three-fourths mile northwest of Ponca Landing, Nebr.*

| | Feet. |
|---|---|
| Loess and till | 80 |
| Greenhorn limestone: | |
| Limestone, weathered, sandy; contains many casts of *Inoceramus labiatus* | 8–9 |
| Limestone, bluish gray, massive, chalky | 10 |
| Graneros shale: | |
| Clay, bluish, stratified | 20 |
| Clay, dark or bluish, at places rusty | 25–30 |
| Shale, dark, quite hard | 2 |

[a] Geology of Dakota County, Nebr.: Proc. Acad. Sci. of Sioux City, Iowa, 1903–4, vol. 1, p. 150.

*Carlile shale.*—This uppermost division of the Benton group begins to appear above the Greenhorn limestone in eastern Dixon County and thickens westward to 170 feet in northwestern Dixon County to over 200 feet at Niobrara, and to 500 to 700 feet in the Black Hills. In the eastern part of its outcrop area it erodes rapidly, forming slopes over which loess and Glacial drift slide from above, concealing it at many points in the bluffs of Dixon County. The base of the formation reaches the level of the river just west of the so-called Ionia Volcano, northwest of Newcastle. The upper surface is about 140 feet above the river level in sec. 28, T. 32, R. 4 E., 97 feet above at Vermilion Ferry, 71 feet above northeast of St. James, 30 feet above north of St. Helena, and reaches the level of the river about 4 miles beyond the last-named town. Recent slides northeast of Ponca expose 8 to 12 feet of Carlile above Greenhorn limestone in the vicinity of the ferry. A well-marked line of contact with the Niobrara chalk above is shown in Pl. V, *A*.

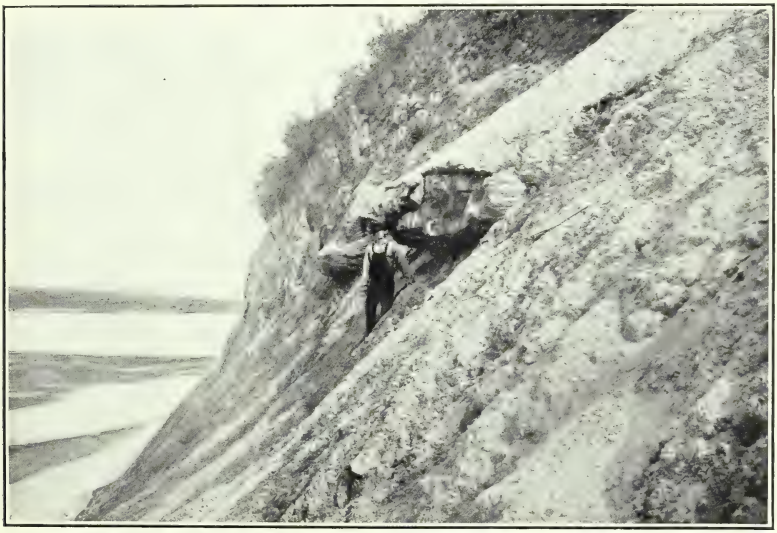
The formation is composed principally of dark-gray and bluish-gray stratified clays, with two zones of fossiliferous chalky shale. Sandstone beds of variable extent and character generally occur at different levels, but usually near the top, as just west of Vermilion Ferry. Large concretions of carbonate of lime are found above the middle of the formation. Drillers in penetrating this formation experience difficulty with the hard concretions and sandstone and with the thin layers of iron pyrites which also often occur in it. Many fish-scales, a large, flat form of *Inoceramus*, *Prionocyclus*, *Serpula*, and *Ostrea congesta* are common fossils.

A locality in northern Dixon County, in sec. 10, T. 31, R. 5 E., has received the name Ionia Volcano. It is simply a bluff of shale in which the oxidation of a large amount of iron pyrites often produces considerable heat, at times sufficient to give rise to steam and sulphur fumes, and even to cause slight baking of the shale.

Two zones of concretions of carbonate of lime occur in the Carlile shale. The lower zone is a continuous one, and its concretions are large, lens-shaped forms, 2 to 8 feet long and 1 foot or more thick (Pl. V, *B*). This horizon continues at about 50 feet from the top of the formation from high in the slope in sec. 32, T. 32, R. 5 E., to a point between St. James and St. Helena, where the dip takes it down to the level of the Missouri. The upper zone consists of smaller concretions at a less continuous horizon 8 to 10 feet above the first. These concretions weather out and fall to the base of a slope, where they crack into irregular pieces. In many of them calcite and selenite crystals occur.

While selenite crystals may be observed throughout the Graneros, Carlile, Niobrara, and Pierre, they are most abundant on slopes of the Carlile formation, especially at the Ionia Volcano or on other

*A*. CARLILE SHALE OVERLAIN BY NIOBRARA NORTHEAST OF JAMES, NEBR.



*B*. CALCAREOUS CONCRETIONS IN CARLILE FORMATION WEST OF VERMILION FERRY, NEBR.

bluffs in that region, where they are commonly mistaken for mica. They vary in size from minute needles to 2 to 3 inches across. They originate near the surface from the weathering of the iron pyrites scattered through the clay, some of the products of which react with lime in solution in percolating waters, forming calcium sulphate which crystallizes as selenite. The usual belief that they were formed when the strata were deposited and that they occur in large numbers throughout the beds is therefore erroneous.

*Section of Carlile shale and associated formations at the Ionia Volcano, in northern Dixon County, Nebr.*

| | Feet. |
|---|---|
| Loess and till | 15–35 |
| Clay (Carlile), dark, plastic. Contains sulphate of iron, epsom salts, selenite crystals, etc., over the surface. Sulphur dioxide fumes rise from the clay at one point | 112 |
| Shale, bluish | 15 |
| Limestone, slabby, with fish scales and *Inoceramus labiatus* | 1½ |

Altitude of river, 1,118 feet; of top of hill, 1,265 feet.

The lowest bed is a part of the Greenhorn, while the overlying bluish shale is a transition to the base of the Carlile. It is prominently represented in a ravine below the old landing about 1 mile away.

Professor Todd has noted the existence of a thin but very persistent layer of clay closely resembling bentonite near the middle of the Carlile formation. It varies from 1½ to 3 inches thick. At Vermilion Ferry it is about 10 feet above the river. At the Ionia Volcano it is about 100 feet above the top of the Greenhorn beds, and it is at same horizon in ravines in the SW. ¼ sec. 26, T. 31 N., R. 5 E., and in a shaft in the SW. ¼ sec. 24 of the same township. It is suggested that it may originally have been a thin stratum of volcanic ash.

### NIOBRARA FORMATION.

The Niobrara formation lies between the Carlile and the Pierre shales and is a conspicuous and characteristic feature of the region. It outcrops in the creek slopes of northwestern Dixon County, high in the river bluffs just west of Vermilion Ferry, and thence westward and northward along Missouri River and its tributaries to the great bend of that river in South Dakota. A thickness of about 130 feet remains in the hills northeast of St. James, Nebr., while westward at the margin of the Pierre shale the total thickness is over 200 feet. The easternmost points at which the formation is exposed or found in wells are in the SE. ¼ SW. ¼ sec. 32, T. 32 N., R. 5 E., and the W. ½ sec. 6, T. 29 N., R. 5 E. The dip, which is westerly, is low from St. James to Niobrara, beyond which the upper surface seems to be nearly level with perhaps a slight rise in the direction of Chamber-

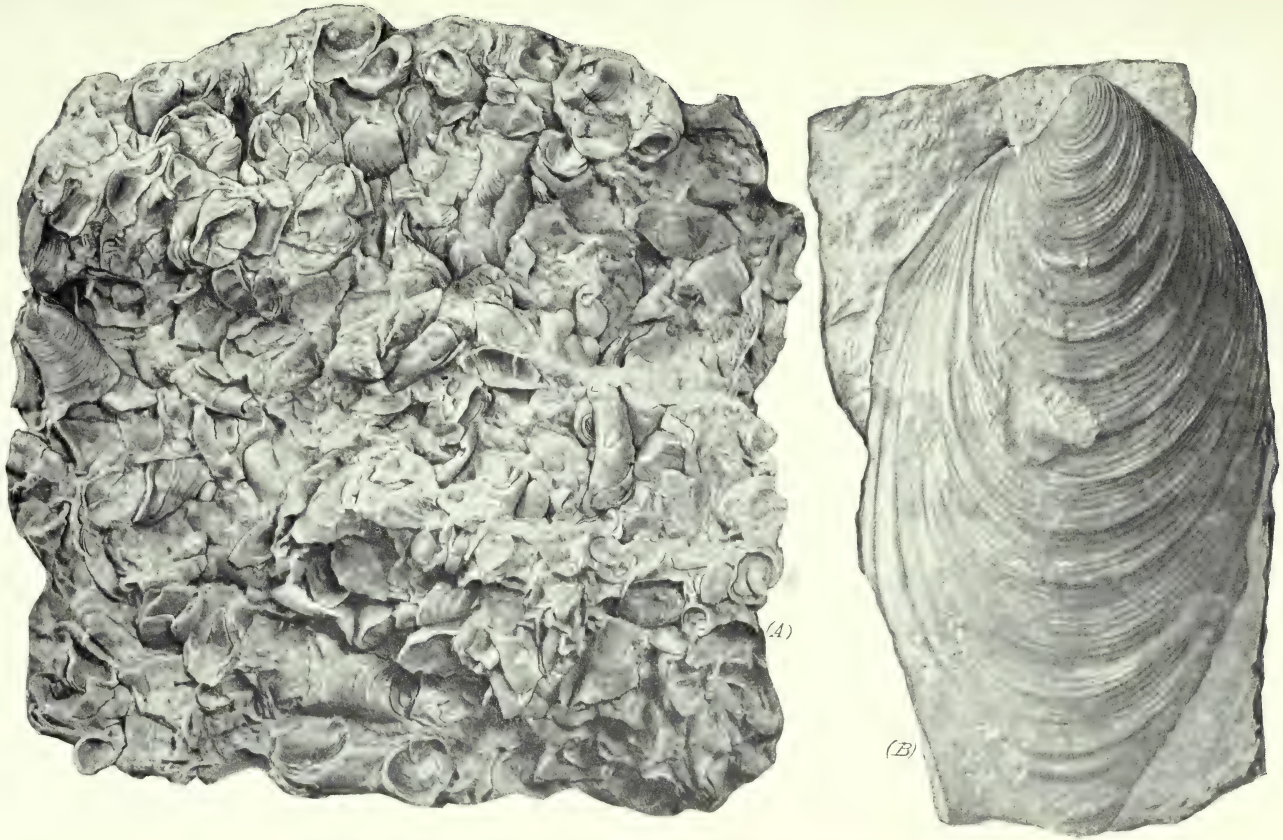
lain, S. Dak. The base of the formation is 97 feet above the river near Vermilion Ferry, 71 feet northeast of St. James, and 30 feet at St. Helena, a few miles beyond which it passes below the level of the river. At the cement works west of Yankton, S. Dak., the upper surface is fully 140 feet above the river surface, while the base lies a few feet below it.

The formation is composed of lead-gray chalk rock, which weathers yellowish, with a variable admixture of clay and sand. Thin limestone beds composed of small *Ostrea congesta*, found principally in the upper portion, are a characteristic feature (see Pl. VI). In Cedar County and apparently at Niobrara, Knox County, the base of the formation is a sandy, hard limestone. The purer chalk beds vary from less than 1 inch to as much as 6 feet in thickness and merge into mixtures of chalk and clay in variable proportions. The upper surface is usually weathered, leaving a relatively larger percentage of clay, iron, and sand than is found in the more massive beds below. In the latter there are nearly vertical joint planes intersecting each other at angles of about 90 degrees. Deeply decayed surfaces have gypsum plates in the joint and bedding planes, and at places selenite crystals are scattered over the surface. The purer massive chalk is of fine grain, porous texture, low specific gravity, and gives a characteristic dead or hollow sound when struck with a hammer. Its economic value lies in its use for the manufacture of cement and for building stone.

The chalk bluffs of the Missouri present a strikingly barren appearance and are usually of a conspicuous yellow color. The bluffs have a uniform height above the river for a distance of over 200 miles in Nebraska and South Dakota, but are notched by many small draws. The upper surface of the formation falls to within 8 or 10 feet of the river at Wheeler and Nieveen, S. Dak. For most of the distance, from a point 5 miles below Greenwood to Yankton, the Niobrara bluffs are prominent on one side of the river or the other. At a number of places slight faults and flexures were observed; most of the latter occur at the mouths of small ravines and appear to be caused by the swelling of beds. The steeper slopes are often covered with splinters of chalk rock broken from the cliffs above.

*Section of Niobrara limestone and associated formations northeast of St. James, Nebr.*

| | Feet. |
|---|---|
| Loess. Rises in hills to an altitude of over 1,400 feet | 40–50 |
| Niobrara chalk, massive, somewhat sandy, and harder in lower beds. Base at 1,205 feet above sea level. Rises in hills to an altitude of 1,335 feet, or a thickness of 130 feet exposed | 40–50 |
| Carlile clay, dark and bluish, with some sand and sandstone. Large calcareous concretions 50 to 55 feet below top. Exposed in slope to river | 71 |




CHARACTERISTIC FOSSILS OF NIOBRARA FORMATION AND GREENHORN LIMESTONE.

*A*, Ostrea congesta; *B*, Inoceramus labiatus.

*Section of Niobrara limestone and Pierre shale on Bazile Creek at bend in road 1 mile south of Bazile Point, Nebr.*

| | Feet. |
|---|---|
| Pierre shale: | |
| Carbonaceous clay, dark in bank, lighter on weathered surface, which is strewn with selenite crystals and small yellowish concretions of irregular form | 6 |
| Niobrara: | |
| Weathered chalk, yellowish, with 3 or 4 light-colored streaks 2 inches thick and about 1 foot apart, *O. congesta* present | 7 |
| Chalk, beds irregular, sandy, and at places concretionary; gypsum plates occur in bedding and irregular joint planes. Lower beds 6 to 8 inches thick. *O. congesta* is the common fossil | 8½ |
| Blue chalk, lower 4 feet in 2 beds; large *Inoceramus* and *O. congesta* present | 8 |

*Analysis of Niobrara chalk rock.*

[Howison Crouch, analyst.]

| | Unweathered specimen. | Weathered specimen. |
|---|---|---|
| Moisture | 0.70 | 1.11 |
| $SiO_2$ | 4.52 | 6.02 |
| Organic matter | 3.14 | 1.03 |
| $SO_3$ | 2.14 | .85 |
| $CO_2$ | 37.80 | 37.11 |
| CaO | 49.66 | 47.98 |
| $FerO_3$ and $Al_2O_3$ | 1.87 | 5.92 |
| Mg | Trace. | Trace. |
| | 99.86 | 100.02 |

## PIERRE SHALE.

The Pierre shale is the thickest member of the Cretaceous in Nebraska, varying in thickness from a few feet in northwestern Cedar County to over 500 feet in western Boyd County. The base, lying on the Niobrara, slopes down slowly from western Cedar County to central Knox County, beyond which it is either horizontal or has a slight rise westward. The eroded top reaches an altitude of over 1,900 feet in western Boyd County. At the cement works, 4 miles west of Yankton, S. Dak., the Pierre clay just above the Niobrara chalk is distinctly crumpled, a feature which may have been caused by the ice sheet.

During Eocene and early Miocene times this region was a land area eroded into hills and valleys. The Pierre clay was entirely removed in the eastern part, and on the rough upper surface later Tertiary and Quaternary deposits were laid down, to be themselves in turn partly removed by weathering and erosion.

The Pierre shale is commonly called "gumbo" and "soapstone," and consists principally of dark and bluish, plastic, and finely stratified clays. It carries lenses of limestone, and beds of shale, impure chalk, and thin layers of concretionary ironstone. At its base there is

a dark carbonaceous clay, resembling coal, which is exposed along the Missouri, beginning in irregular lenses near Chamberlain, S. Dak., and extending as a continuous, well-marked horizon from a few miles farther down the river to eastern Knox County. At the latter place it contains, near the middle, an admixture of whitish clay, resembling fuller's earth and varying in thickness from 10 to 30 feet or more. The next horizon above is made up of dark and bluish plastic clays with thin seams of iron ore. Above this are alternating beds of shaly chalk and clay, the former weathering reddish; these chalky beds are often mistaken for Niobrara chalk. The highest beds of the Pierre, as observed in Boyd County, are bluish clay with some concretions of iron ore. The sections on page 17 give the strata more in detail.

The Pierre shale in this region is not rich in fossils. A few *Inoceramí*, shark's teeth, and mososaur remains were observed by the writer. Mr. R. F. Stout, Center, Nebr., has collected from Pierre chalky beds about 72 vertebræ, the paddle bones, and pieces of ribs of a very large mososaur. He also secured crocodile bones and a number of *Belemnitella*.

The beds do not rise steeply in bluffs but, weathering rapidly, form rolling hills and long slopes. A typical hilly country of Pierre shale lies between Santee and Herrick in what is called the Devil's Nest. The hills, though usually either grass-covered or farmed where not too rough, show light to dark bands at different levels. This appearance is due to the alternation of beds, the chalky deposits causing light bands, the chalk stained with iron giving rise to yellowish soil, and the dark clays and iron-bearing beds giving brownish and dark streaks.

In the high ridge just north of Niobrara River and southeast of Spencer, certain hard beds at different levels cause flat summits or a series of irregular steps rising from east to west. The topography of the different zones of the Pierre is well shown along Bazile Creek, which has a grade of about 400 feet in 24 miles. Gradual clay slopes extend from altitude 1,560 to about 1,500 feet; steeper, chalky slopes with a narrower valley extend from altitude 1,500 to 1,400 feet; while the clays below give more gentle slopes and a wider valley down to about 1,280 feet, at which altitude the Niobrara chalk begins and bluffs prevail.

A very noticeable feature, especially in northern Holt County, is the presence along Niobrara River and its tributary creeks of many landslides, caused by the infiltration of ground water through joints in the clays, rendering them plastic. Fully 50 slides may be seen along Eagle Creek, between Turner and Ray, where Pierre clay rises from 60 to 100 feet in the slopes. At John Dolin's place, in sec. 26, T. 32, R. 11, a slide formed in 1893 has a length of 20 rods and ver-

tical displacement of from 50 to 100 feet. It completely dammed Eagle Creek, causing the channel to shift several rods southward.

*Section of Pierre shale along Bazile Creek ¼ mile southeast of Mackeyville, Nebr.*

| | Feet. |
|---|---|
| Bluish clay with flakes of iron oxide on surface | 79 |
| Dark, carbonaceous clay which, at places, is chalky, extending below the water in the creek | 12 |

*Section of Pierre shale and Niobrara limestone south of the Missouri River and 3 miles west of Fort Randall, S. Dak.*

| | Feet. |
|---|---|
| Pierre shale: | |
| Clay with ironstone over surface; some selenite above | 13 |
| Clay, yellowish, chalky, varies in character from massive, impure chalk to large concretions of chalk and clay. Dark, flat concretions occur at base | 11 |
| Clay, very dark; carbonaceous with thin, light-colored seams at base; definitely jointed, standing as buttresses, between which it weathers into amphitheater-like recesses; surface lighter where weathered; gypsum flour and selenite in joint and bedding plains. Lemon-yellow concretions occur near top of beds | 28 |
| Niobrara: | |
| Chalk, weathered above, darker below; with few fossils | 40 |

*Section of Pierre shale and overlying deposits, one-half mile northeast of Center, Nebr.*

| | Feet. |
|---|---|
| Loess | 4 |
| Sandy slope | 9 |
| Pebbles and gravel, then fine sand and glacial pebbles at base | 30 |
| Pierre shale: | |
| Dark clay, somewhat chalky when dry | 1½ |
| Light buff-colored clay, bedding not plain, showing gypsum flour and small selenite crystals in joint and bedding plains | 4½ |
| Clay, light, blue, or dark at places; chalky and hard. Rosettes of selenite common over upper 2 feet. Gypsum flour in cracks; crystals in joint and bedding plains | 19 |
| Clay, dark gray | 2 |
| Clay, dark, plastic, with 3 to 6 inch zone of oxidized iron concretions 32 feet below top. This clay seems to extend below the creek. Exposed | 45 |

*Section of Pierre shale above the Whiting Bridge, 7 miles southeast of Spencer, Nebr.*

| | Feet. |
|---|---|
| Clay, dark, plastic, with thin seams of iron | 170 |
| Yellowish clay, darker where not weathered, with some portions bluish | 40 |
| Chalky beds, at places hard enough for building purposes | 2 |
| Alternating dark shale and clay; the shaly beds stand out as buttresses | 36 |

Altitude of river, 1,502 feet; top of slope, 1,750 feet.

## TERTIARY SYSTEM.

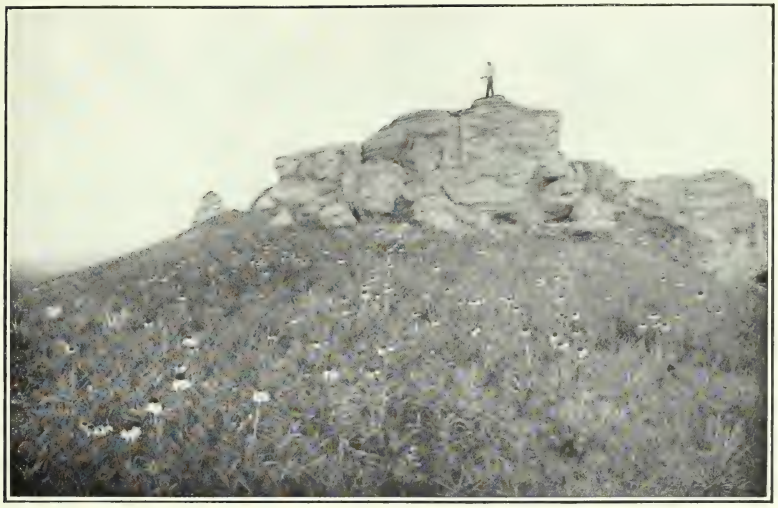
Two formations of later Tertiary age occur in this region: one is the Arikaree, which has a wide range over western Nebraska and adjacent States; the other, which has no name, consists of certain stratified sands and clays found in Holt, Knox, and Cedar counties.

### ARIKAREE FORMATION.

The Arikaree formation is composed of grayish sand and sandy clays, with local beds of sandstone, quartzite, conglomerate, and fresh-water limestone, which, in the table-lands of Boyd, Holt, and Knox counties, are 100 feet or more thick. From these nearly level areas the formation thins on the slopes and ridges toward and between the streams. Certain outliers in the eroded areas give rise to buttes of more or less prominence. Originally the formation extended over all of the western part of the region to which this report relates and well into Cedar County and perhaps farther east, but by subsequent erosion it has been widely removed, leaving only a few remnants, capping buttes on some of the northwest-southeast trending ridges to the east.

The sandy portion of the formation is in part unconsolidated, the grains usually being feebly cemented by a small amount of calcium carbonate. Where there is more complete cementation there are local beds of sandstone which generally show cross-bedding. In several cases the rock contains pebbles. In most of the buttes there occurs a hard, greenish sandstone or quartzite with a silicious cement, identical with that found in the Bijou Hills of South Dakota and at Woodruff, Kans. These hard beds do not occur at definite levels, the nature and kind of the rock often changing within a few feet.

Not many fossils are found in the Arikaree formation. Silicified wood is abundant on the place of Andrew Lukup, southwest of Verdigre. Several mammalian bones have been found about the buttes, but the writer saw only one bone of that class embedded in the rock. The most conspicuous outcrops are in the well-known Twin Buttes, 10 miles west of Butte, Boyd County (Pl. VII, A), and Stony Butte, 2 miles southwest of Verdel, Knox County. Twin Buttes, 2,060 feet in altitude, are so prominent that they can be seen for many miles, even from points in South Dakota beyond Missouri River. From the top of the southeast butte, which rises over 100 feet above the plain, a good idea can be gained of the former extension of the Arikaree table-land north in Dakota, west in Keyapaha County, and south in Holt County. The altitude of Stony Butte is about 1,700 feet; in it the Pierre clay is capped by 25 feet of Arikaree formation, the latter being composed of cross-bedded sandstone and quartzite, with a small amount of sand at the base. As



*A*. ONE OF THE TWIN BUTTES, BOYD COUNTY, NEBR.

*B*. KNOLLKEMPER DAM, TURNER, HOLT COUNTY, NEBR.

this sand crumbles out or washes away, the hard beds above are undermined and break into large pieces or bowlders which scatter over the Pierre slope below.

*Section of Tertiary deposits in bluffs northeast of Badger Bridge, Boyd County, Nebr.*

| | Feet. |
|---|---|
| Sand and gravel in slope | 38 |
| Sandstone, quartzitic, greenish to light, cross-bedded, weathers to light color | 2 |
| Sandy loam, grayish, light on surface, darker in bank; not plainly stratified; contains in upper part hard concretions 6 to 8 inches in diameter. These break into irregular pieces showing dendritic structure | 7 |
| Loam, grayish, sandy, weathers to a yellowish or buff color, resembling loess; lies on Pierre shale at an altitude of 1,800 feet | 62 |

*Section of Tertiary deposits at the southeast Twin Butte, Boyd County, Nebr.*

| | Feet. |
|---|---|
| Sandstone; 3 feet top of grayish to greenish and quartzitic, the rest friable, cross-bedded, and showing plant-like tubes | 10–15 |
| Gray sand | 5–10 |
| Porous rock consisting of sand and pebbles in a limy matrix | 6–10 |
| Clayey sand, greenish in beds, grayish on surface | 90? |

In a field just north, and at the top of the bluffs along Keyapaha River, this lower sand is underlain by a bed of greenish quartzite, beneath which is a bed of loam lying on Pierre clay.

### PLIOCENE DEPOSITS.

At the close of Arikaree time the region was extensively eroded by drainage, which for a while at least flowed from northwest to southeast. A few remnants of the deposits of these old, high-level streams may be seen extending southeast across Gregory County, S. Dak., and at other points farther west. The longer axes of the buttes of Arikaree formation in Boyd County extend in the same direction. Parts of northeastern Nebraska were considerably eroded at this time, but finally received the sand and gravel deposits which are thickest to the east and south. The old channels extending across Knox and Cedar counties and described by Prof. J. E. Todd[a] may have been outlined at that time, for they appear to be related to the old channels farther northwest. Old valleys connect Ponca Creek and Niobrara River in secs. 25, 26, and 36, T. 34 R. 14, and south of the buttes near Butte. Sandy gravel-capped ridges trending northwest-southeast, with intervening dry valleys, occur at various places, notably southwest of Butte.

The so-called Pliocene deposits consist principally of stratified sand with some gravel and clay, which comes to the surface in southeastern

[a] Todd, J. E., Moraines of southeastern South Dakota: Bull. U. S. Geol. Survey No. 158, 1899, pp. 60–61.

Holt and southwestern Knox counties and lies beneath loess and glacial drift in much of Knox and Cedar counties. The best typical exposures occur in the Devils Nest region between Santee and Herrick, where a thickness of 50 to 100 feet has been observed. The relations of these beds to the Arikaree drift and loess has not been fully ascertained; while they are usually described under the name Pliocene it seems highly probable that the accumulation of much of the formation so characterized extended well into Quaternary time.

## QUATERNARY SYSTEM.

Deposits belonging to this system consist of glacial drift, loess, alluvium, and dune sand.

### GLACIAL DRIFT.

The drift is composed of irregular masses of bowlder clay and of sand and gravel beds with an admixture of bowlders at places, these materials having been carried to the region by the glacial ice sheet and streams. The bowlder clay is exposed lying on the Cretaceous and Tertiary deposits at various points along the deeper valleys, and is reached in wells at a number of places; it frequently contains northern pebbles and bowlders. Gravel and sand beds are of wide extent under the loess; they rise to an altitude of over 1,600 feet in northwestern Knox County, where they mix with somewhat similar materials of western origin. Along some of the principal streams the gravel beds appear as a terracelike cap. Bowlders occurring in connection with the gravel are found along the streams and on hill slopes in Knox and Cedar counties, where, as a result of undermining, they fall or roll to lower levels; one of the most conspicuous deposits extends from 1 to 3 miles north of Hartington. In Dixon and Dakota counties they seem to be buried beneath the loess and to be in small numbers, as well drillers rarely find them. The western limit of northern drift extends from near Verdel southward along Verdigris Creek.

### LOESS.

This important surface formation, often called the Bluff deposit, extends over most of Nebraska east and south of the sand hills, and into Iowa, Missouri, Kansas, and other States. It is composed of fine sand and clay particles and contains a small amount of calcium carbonate which holds the grains together loosely. The nearly universal buff color is due to the presence of a small amount of yellow oxide of iron. The thickness varies from a few feet to over 100 feet. Its most noticeable feature is the uniformity of porous texture and massive structure throughout, with only occasional traces of stratification. In western Knox County the loess becomes sandy or changes to a loesslike silt. A close examination of a loess bluff shows

faint vertical cleavage and usually the presence of small, light-colored, irregular concretions. Very small shells, usually of land forms, occur at many localities.

The origin of the loess is still a disputed question, some geologists holding that it is a wind deposit, while others claim that it has been deposited in water. From its character and relations in this region, it seems probable that the principal agency has been wind, but the deposits were locally modified by water.

The eastern part of the area described in this report has a hilly loess topography. Near Ponca many vertical slips due to the vertical jointing were observed in the hills, where they are locally called "cat steps." The vertical displacement causes the formation to slide over and cover banks in which older formations occur. Where the talus is removed from below by a stream or other agent, nearly vertical loess bluffs result.

Near Cook Creek, close to the east side of the Santee Indian Reservation, a loess escarpment begins as a bluff rising from 100 to 200 feet above the Cretaceous clays in the Devils Nest below. This high ridge extends southeastward and then curves northeastward to a high hill 4 or 5 miles southwest of St. Helena. The noticeable feature is that the slope is southward from the brink of this escarpment. The loess similarly slopes away from the brink of the Missouri Valley just south of Vermilion Landing, Cedar County.

### ALLUVIUM.

Alluvial deposits composed of sand, clay, and some gravel, floor the principal valleys. These deposits have also been called valley wash and bottom land, while their upper surface is referred to as a flood plain. Level areas of the same nature but somewhat higher, are called benches or alluvial terraces. The alluvial flats along Missouri River vary in width from about 2 to over 10 miles, being widest along Dixon and Dakota counties; between Jackson and Homer they form the extensive bottom lands.

Alluvial materials comprise flood-plain and alluvial-fan deposits. The former have been deposited principally by the Missouri, while the latter, which are well shown between Ionia and Ponca, have been carried from adjacent slopes by weak tributaries, and scattered over the flood plain at the mouths of ravines. The thickness of the alluvium averages much greater than the depth of the river channel; a thickness of 185 feet is reported in the Joseph Holtzbauer well near Aten.

The bottom lands along the Niobrara average from one-half to three-fourths mile wide and are very sandy. Nearly all of the smaller streams flow on narrow beds of alluvium.

#### DUNE SAND.

In certain areas the wind has blown Arikaree, Pliocene, and alluvial sands into small dunes or sand hills. The principal area lies south of Niobrara River, and is from 5 to 8 miles wide, extending from the western part of Holt County to near Bazile Creek. A few small "blow-outs" occur on the highland west of the town of Verdigre. Low sandy ridges, extending in a northwest-southeast direction, occur at several points in Knox and Cedar counties; they were formed earlier than the dunes on the alluvial flats. At a number of places the loess is completely covered by drifting sands. A few small dunes are found on the Logan Creek bottom, near Laurel.

## ECONOMIC GEOLOGY.

### MINERAL RESOURCES.

#### BRICK CLAY.

Cretaceous clays and the loess are used successfully in the manufacture of brick. Twelve brickyards were operating in the region in 1903.

#### SAND AND GRAVEL.

Building sand in unlimited amounts is found along Niobrara and Missouri rivers, and is plentiful in the Tertiary and Quaternary formations. The principal loading station is at Stewart, Holt County, where the sand is scooped onto cars and sent out by trainloads. Gravel suitable for ballast occurs in terraces and in the glacial deposits at many places. Glacial bowlders have been used as foundation materials.

#### BUILDING STONE.

No very attractive and durable stone is found in northeastern Nebraska, and that available occurs under unfavorable conditions. The stone most used is the greenish Arikaree quartzite described on page 18. It is hard and fairly durable, but works in poor form, as the deposits are of very irregular character. It is quarried in most of the stony buttes and at a few lower levels, and is used principally for foundations and milldams. Most of this material is obtained (1) from many places in northern Holt County, as at Ray and Turner, where it is found in residual bowlders; (2) at John Vicknish's quarry, near Ray; (3) northeast of Badger Bridge; (4) in the vicinity of Twin Buttes; (5) just south of the town of Butte; (6) 3 miles north and one-half mile west of Spencer; (7) at the Stumbo quarry, in sec. 20, T. 33, R. 10 W., between Lynch and Gross; (8) on the divide south of Monowi; (9) on Stony Butte, 2 miles south of Verdel; (10) 6 miles southwest of Verdigre; (11) on the divide between Verdigre

and Center, and (12) 2 miles southwest of Aten. The quartzite is excellent for concrete work and it would make very fair ballast if crushed.

The Greenhorn limestone is used somewhat for foundations, and the Niobrara chalk, though soft, serves fairly well as a building material where it can be placed above ground water. In some houses it has stood over twenty years with little sign of decay. The Menominee Church, in northern Cedar County, and the house of C. D. Buhro, sec. 20, T. 32, R. 2 W., Knox County, are good examples of this.

The lens of limestone in the Pierre formation 7 miles northwest of Verdigre has been used to some extent as a source of building stone, but there is only a limited supply of it and considerable stripping is necessary.

At Jackson, Homer, and a point 5 miles southeast of Homer, a fair grade of sandstone is found in the Dakota, but the conditions for quarrying are not favorable.

### CEMENT ROCK.

A large portion of the chalk rock of the Niobrara formation is suitable for cement manufacture and, with the growing demand for Portland cement, the production of this material may prove profitable in northeastern Nebraska. It is now manufactured extensively across the river in South Dakota, in mills located 4 miles west of Yankton and 1½ miles north of the river. The plant has been running thirteen years, supplying cement to South Dakota, Iowa, Nebraska, and other States; the output is 300 barrels a day, with 60 men working. The materials used average about 4 parts of Niobrara chalk to 1 part of Pierre clay. The top of the chalk here is weathered and has to be stripped to a depth of about 15 feet. The chalk and clay are mined or quarried, crushed together, thoroughly mixed, and then carried by water slushes to drying vats, where the mixture is dried by solar heat, and separated into blocks. Then come kiln burning, final grinding, and preparation for shipment. A view of the works is shown in Pl. VIII, *A*.

The formations worked at Yankton are exposed in Nebraska along Missouri River from Dixon County to northern Boyd County and afford a vast supply of the raw materials. The principal factors to be considered in the establishment of a plant, besides the presence of suitable cement materials, are the condition in which they are found so as to avoid waste in quarry strippings, the water supply, fuel, and a suitable location, especially in relation to transportation facilities. All of these conditions except cheap fuel exist at many places on the Nebraska side of the river. At Niobrara the chalk rock is of good quality and in large supply, and this place is favorably situated for railroads and river transportation; artesian water and a suitable loca-

tion for a plant can also be had. A view of an outcrop at this place is shown in Pl. VIII, *B*.

### COAL.[a]

For nearly fifty years there has been more or less prospecting for coal in northeastern Nebraska, but the results have been most unsatisfactory. Near Ponca Landing, from 10 to 18 inches of an inferior grade of lignite is found in the basal portion of the Graneros shale, and it has been worked in a limited way. Near Jackson two holes were recently sunk, which found two thin beds of lignite in the Dakota. In a high bank southeast of Homer a thin bed of lignite rises 85 feet above the river. Paying quantities of coal are not to be expected in this region. The following analyses of Dakota County lignite, by Mr. E. F. Burchard, may be of interest in this connection:

*Analysis of air-dried lignite from near Jackson, Nebr., at a depth of 65 feet.*

[E. F. Burchard, analyst.]

| | |
|---|---|
| Water | 4.03 |
| Volatile matter | 51.40 |
| Fixed carbon | 33.66 |
| Ash | 10.91 |
| | 100.00 |

Sulphur undetermined.

*Analysis of air-dried lignite from shaft near Jackson, Nebr., depth 82 feet.*

[E. F. Burchard, analyst.]

| | |
|---|---|
| Water | 6.47 |
| Volatile matter | 27.24 |
| Fixed carbon | 49.27 |
| Ash | 16.23 |
| Sulphur | .86 |
| | 100.07 |

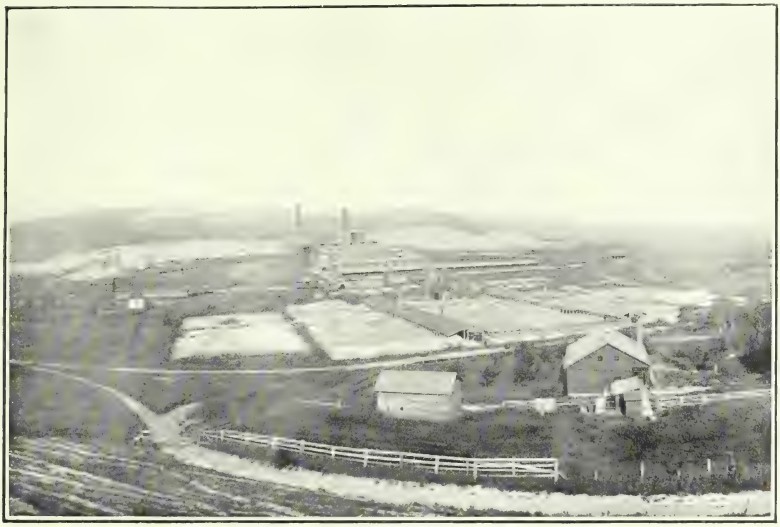
### PEAT.

While there has been no development of peat as a source of fuel in any part of the area, it seems probable that it may be found in considerable quantities in some of the boggy basins. One of the localities that should be investigated is the basin of Perrin Creek, in Cedar County.

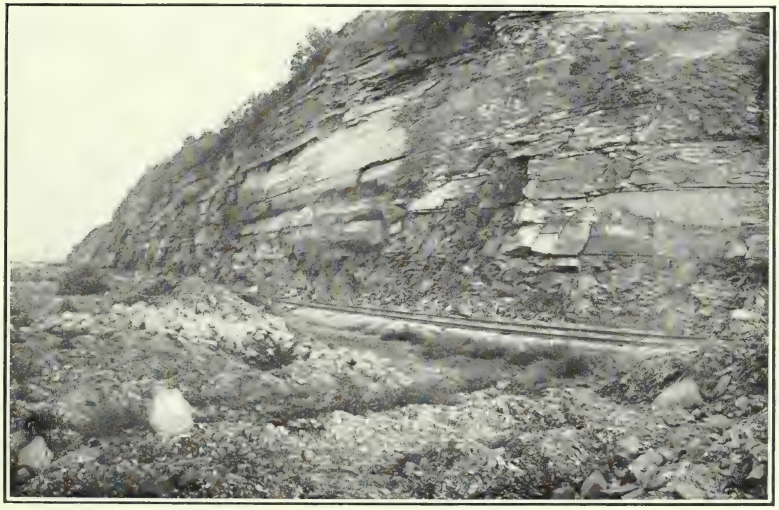
### VOLCANIC ASH.

Volcanic ash beds which may yet prove of some importance occur in Holt, Knox, and Dixon counties.

[a] Extended accounts of the lignites of Dakota County are given by E. F. Burchard in Contributions to economic geology for 1903: Bull. U. S. Geol. Survey No. 225, 1904, pp. 276–288; and in Geology of Dakota County, Nebr.: Proc. Acad. Sci. and Letters of Sioux City, 1903–4, vol. 1, p. 150.



*A*. CEMENT PLANT NEAR YANKTON, S. DAK.



*B*. NIOBRARA FORMATION JUST WEST OF NIOBRARA, NEBR.

## WATER RESOURCES.

### GENERAL STATEMENT.

Of the water which falls upon the land, part runs off into surface streams, part evaporates, and part is absorbed by the land and by plant growth. The proportions vary with the rainfall, soil texture, geologic structure, and topography, the volume of rainfall being the most important factor. In northeastern Nebraska the rainfall varies considerably in the different counties, with a general diminution from east to west, the normal annual precipitation ranging from 27 to 28 inches in Dakota, Dixon, and Cedar counties to less than 23 inches in parts of Boyd and northern Holt counties. Mr. George A. Loveland, meteorologist at the University of Nebraska, gives the following data:

Normal annual precipitation at Agee, Holt County, 23.87 inches; Lynch, Boyd County, 23.33 inches; Santee, Knox County, 22.78 inches; Hartington, Cedar County, 27.53 inches; Elk Point, South Dakota, 27.61 inches. The maximum amount of rainfall is in May and June, or during the growing season. Nothing definite is known concerning the amount of evaporation from different soil surfaces in this section. The maximum evaporation is during June, July, and August.

The absorbent power of the soil is greatest in the loess and sandy areas which occupy much of the area. On certain clayey soils on steep slopes the run-off is large, notably on some of the Pierre lands. Water absorbed and collected in the soil is called ground water; it moves slowly downward until it reaches some impervious layer, above which it accumulates in varying amounts, in many areas completely filling or saturating thick beds of sand. The ground water moves slowly from higher to lower regions, at a rate which is greatest in coarse or porous beds. Heavy rains raise the upper surface of the ground water, while long dry spells, when evaporation is greatest, lower it.

A few lakes in the sand hills north of Turner show well this rise and fall of the water table, filling up during wet weather and disappearing at dry times. During the dry years 1893 to 1895 the water table lowered very perceptibly, while during 1903 it rose and numerous new springs appeared at the surface. The ground water also is the source of the shallow wells' supply.

### SURFACE WATERS.

#### STREAMS.

The Missouri River carries a large volume of water, and although its grade is less than 1 foot to the mile it flows rapidly. It is important as a source of water for drinking, domestic purposes, and stock. Many persons drink the turbid water as it comes from the

river, but in most cases it is settled in vats before using. While it affords a good supply of stock water, many cattle and a few horses are lost each year by falling into the river at caving banks. These unfortunate animals rarely escape, for, although they gain a footing at some sloping bank, they usually can not climb out, and finally die from exhaustion. The Missouri is also an important avenue for transportation by means of steamers of small size, which carry grain, stock, lumber, and passengers.

Niobrara River receives most of its water from springs at the base of the Arikaree formation. The following discharge measurements were made near the village of Niobrara:

*Discharge, in second-feet, of Niobrara River near Niobrara, Nebr.*

| Date. | Hydrographer. | Discharge. |
|---|---|---|
| April 6, 1901 | O. V. P. Stout | 1,591 |
| April 7, 1901 | do | 2,115 |
| May 11, 1902 | J. C. Stevens | 1,637 |
| July 6, 1902 | do | 2,021 |
| July 25, 1902 | do | 1,401 |
| August 21, 1902 | do | 1,106 |

The stream is shallow and relatively swift, flowing among many sand bars. The water is not deep enough for boating. In this section the south slopes are usually sandy, while those on the north are clayey and very steep. Except for stock and locally for domestic purposes the water is not extensively utilized.

Ponca Creek is a weak stream in a large basin. It heads in south-central South Dakota, in many broad, shallow valleys which carry but little water.

Many water powers available in this region could be utilized to advantage. While power sites are found in each county, the most favorable conditions prevail in Knox and in the northern part of Holt County, where the powers are mostly on the smaller or spring-fed streams, which are not much affected either by floods or dry weather; these have steep grades and keep open most of the winter. As the country becomes more populous there will be increasing demand for water power, which is little used now except to run a few flouring and grist mills.

### SPRINGS.

Springs are an important water resource in all the counties, affording most of the local water supply. The principal horizons from which they flow are (1) between the Tertiary sands and the Pierre clay, (2) between Glacial drift and the Pierre, and (3) from the Dakota sandstone.

The porous Arikaree formation contains a large supply of ground water which sinks to the impervious Pierre clay, along the top of

which it flows until it reaches the surface on the hill slopes. This condition is shown by the existence of frequent springs at the base of the Arikaree sands, whence the water flows out over the clay slopes below. This horizon lies high on the slopes in the western parts of Holt and Boyd counties and somewhat lower in Knox. In all cases the same general conditions prevail—an impervious bed checking the downward motion of water accumulating in a porous formation, and a lateral flow to the surface. The water from a series of springs often collects into a flowing stream, but, on the other hand, soil often chokes or checks the flow, especially in pasture lands where cattle and horses assist the process by tramping. During exceptionally humid years, ground water reaches the surface at additional places, producing transient springs. These are often called wet-weather springs, and are evidence of extensive seepage not far back in the slope which, by suitable trenching, can often be opened so as to furnish a permanent flow. Sometimes a short horizontal well or tunnel will reach a permanent supply. Where the formation is not too sandy the same result can be accomplished by boring and drilling.

Boggy places, where the ground water seeps to the surface, occur along certain streams in each county. The springs coming from the Dakota sandstone are, in part at least, seepage from the artesian waters, a portion of which reaches the surface in the eastern part of the area to which this report relates.

## UNDERGROUND WATERS.

### SHALLOW WELLS.

Shallow wells, like most springs, draw their supply from the ground water. The amount of water which a well will afford within a given time depends on a number of conditions, the principal one of which is the nature of the pervious bed. Thoroughly saturated gravels and coarse sands deliver water faster than fine sand. As water is pumped from the well the surface of the water lowers, but this is slow and hardly perceptible in cases where the materials are coarse and there is an abundance of water. It is desirable, therefore, to find water-bearing beds of coarse sand or gravel, and material of this sort prevails at most localities in this region. The water from the Cretaceous formations is generally bad, except that from the Dakota sandstone, and even this is often charged with mineral matter. The Tertiary and Quaternary deposits generally yield a suitable supply of water of good quality. Wells, except the deeper tubulars, vary in depth from a few feet to between 200 and 300 feet, and in diameter from 2 inches to several feet. They are cased with wood, brick, tile, cement, stone, and iron pipe, the first named being mostly used, and the last named being used in driven wells. Wells are dug, drilled, bored, and driven. The water level in most shallow wells is affected

somewhat by weather changes. Those on the Missouri bottom, when near the river, seem to fluctuate somewhat with the flood and low-water stages of the river.

### ARTESIAN WELLS.

*Artesian conditions.*—The entire area treated in this report is underlain by the water-bearing Dakota sandstone, which yields artesian wells in many districts. Part of this water comes to the surface in numerous springs in Dixon and Dakota counties, but to the west it lies at depths gradually increasing to 1,500 feet or more. The source of this water is in the Black Hills and the Rocky Mountains, where the Dakota and associated sandstones are extensively exposed. Thence this sandstone dips eastward beneath later Cretaceous clays, but it comes to the surface along Big Sioux River, in Iowa, and also along Missouri River below Ponca, Nebr. The sandstone is porous, and also thick enough to receive and carry large amounts of water. The supply is gathered in the mountain areas and flows very slowly through the sandstone to the lower regions east, where (as, for instance, along the valleys and lower lands of Nebraska and South Dakota) part of it comes to the surface through springs and artesian wells. An important factor is the thick mass of impervious clay and shale overlying the water horizon and preventing its escape in the wide area of plains between the mountains and the Missouri. Such beds overlie the Dakota sandstone as far east as Ionia, Nebr., in the river valley and somewhat farther on the highlands. Talus slopes, glacial clays, and fine sands aid greatly in checking the free escape of water in the eastern outcropping area. Owing to the high altitude of the gathering grounds on the mountain slopes, 4,000 to 5,000 feet, and the low altitude of the region east, the water is under such pressure or head that it flows slowly eastward through the porous sandstone.

The Carboniferous beds which underlie northeastern Nebraska carry artesian water, but at a considerable depth. This horizon was reached in wells at Sioux City, Iowa, and at Ponca, Nebr.

The sandstone of the Carlile formation carries artesian water and yields the weak "pencil" flow or "straw" flow of Knox and Cedar counties. Some of the artesian springs farther up the river may issue from this horizon.

*Chemical composition of artesian water.*—The chemical composition of artesian water seems to vary somewhat with the different flows and localities. The most common mineral compounds present are sulphates of soda, lime, and magnesia, chloride of sodium, and iron, all usually in small amount. There is only a trace of organic impurity.

The following analysis of water from the small school well, Santee, Nebr., was made by Prof. Robert O. Riggs:

*Analysis of water of small school well, Santee, Nebr.*

| | Parts per million. |
|---|---|
| Silica ($SiO_2$) | 9 |
| Aluminum (Al) | 2.1 |
| Calcium (Ca) | 242 |
| Magnesium (Mg) | 48 |
| Sodium (Na) | 87 |
| Potassium (K) | 29 |
| Sulphate radicle ($SO_4$) | 733 |
| Carbonate radicle ($CO_3$) | 84 |
| Bicarbonate radicle ($HCO_3$) | 68 |
| Chlorine (Cl) | 55 |
| | 1,357 |
| Total solids | 1,360 |

The iron was not determined but there is more of it in the water of this well than in that of the large school well.

*Pressure.*—Owing to the elevated source of waters in the Dakota sandstone, these would be under great pressure under the lowlands east were it not for the leakage in the outcrop area which causes the "head" to gradually decrease from west to east. The pressure or head is of great practical importance, for it determines the height to which the water will rise, and consequently the area within which artesian flows are to be expected. This area, deduced from observed pressures, is shown in Pl. IX (in pocket). As the Dakota is composed of alternating beds of sandstone and clay which often are distinct, there are different flows, called "first," "second," "third," etc., which have different pressures or heads, usually greatest in the lowest. This is because there is freer leakage from the upper than from the lower sandstone horizon.

In northeastern Dixon County there is no pressure in the upper sandstone beds of the Dakota formation and only enough in the lower beds to raise water a few feet above the level of Missouri River. Farther west, in northwestern Dixon County and northern Cedar County, the pressure is so small in the upper beds that the flow is not strong, but at lower levels a greater pressure is found.

At Niobrara the pressure is strong enough to force water about 210 feet above the mouth of the Mill well, or to an altitude of 1,450 feet. As above explained, the pressure and head increase from east to west, and if it were not for the fact that the rise of the country is usually more rapid in that direction than the general increase gradient of the water head, artesian water could be obtained over a much greater area. As it is flowing wells are obtainable only in the valleys. At Lynch, at an altitude of about 1,392 feet, there is a closed pressure of 85 pounds to the square inch. Allowing a head per pound of 2⅓ feet (the height of a 1-inch column of water weighing one pound), the water would rise in a pipe 198 feet above the mouth of the well, or to an

altitude of over 1,590 feet. As the well is 923 feet deep there is sufficient pressure to raise water in all 1,121 feet. Dividing 1,121 by 2⅓ we find that the pressure at the bottom of the well is 480½ pounds per square inch.

In the Rosebud Agency well farther northwest, in South Dakota, the artesian water raises to an altitude of 2,000 feet. Different wells in a given locality may show different pressures. The variations may be due to one or more of the following conditions: (1) Difference in the horizon of the flow, the pressure being greater with deeper flows; (2) escape of water outside of the casing; (3) leaks in the casing due to rust; (4) difference in altitude of mouths of wells; (5) choking of flows by sand or clay; (6) proximity of wells causing local interference and decrease below the average pressure; (7) short, loose, or broken casing permitting leakage from a lower sandstone into an upper one.

*Temperature of artesian water.*—In a given locality the temperature is highest in the deeper wells. There is a gradual decrease eastward from over 80° F. in the deep well at Lynch to 54° in one of the Ryan wells in the northern part of Dixon County. It has been observed that the shallow artesian wells with weak pressure have about the same temperature as springs.

*Construction and care of wells.*—It was noted that in many cases but little care had been taken in the selection of proper sites and in the construction of wells in northeastern Nebraska. Some wells have been drilled on land too high for a flow, even when a lower position would have been just as convenient to the owner. Some wells on moderately high lands, which did obtain feeble flows, have since ceased flowing. Wells should be carefully cased, and the casing should fit tightly into cap rock and permit no leakage. Below the cap rock perforated pipe should be used for a part of the distance at least to prevent sand choking the end of the casing. In too many instances there is not enough casing, and it is often so loose that water flows outside of it to the surface. It is best to use double casing. Water standing about the mouth of the well causes the pipe to rust badly, but this can easily be prevented by carefully piping and grading. One of the largest and most expensive wells in the area was lost by the rusting of pipes near the surface; in this case there was a pond of water about the well. In wells with double casing the old inner pipe can be drawn and replaced by a new one.

Large and expensive wells to be used for power should be put down by experienced well drillers who understand how to cut off the upper and weaker flows and produce a well with the greatest possible pressure. It has been found best to keep such wells closed when not in use. If properly cased and not running sand there is

no danger of injuring the well by shutting off the flow, but it should be shut off gradually.

*Diminution in pressure and supply.*—It is believed that in some portions of the artesian area the pressure and volume of flow is diminishing, but reliable data bearing on this point are difficult to obtain. Many wells decrease in volume after flowing some time, but the change is often due to breaks in the pipe, leakage, and clogging by sand or iron rust. Sometimes the diminution is local and due to the large number of wells. It is claimed that the pressure in the first and second flows in the Dakota sandstone is decreasing in Cedar County; the first flow at present runs a 2-inch pipe half full, while formerly it ran a full pipe; the second flow, about 80 feet deeper than the first and having more pressure, shows but little change; the third flow, from 30 to 40 feet below the second, has changed very little, if any.

### BLOWING WELLS.

Blowing wells are found at a number of places in Nebraska, especially in Jefferson County. They are also known as "breathing," "howling," and "weather" wells. They occur at several localities in southeastern Knox County and about Mineola, Holt County. The wells have a depth of from 125 to about 200 feet, passing through loess, sand, dry gravel, and sand into water gravel. In some cases there is only a slight movement of air into and out of the well, called "sucking" or inhalation and "blowing" or exhalation. Where the casing is tight above and the opening small a very audible noise may be produced. The movement of air, up or down, seems to depend on the barometric pressure. When the air is heavy during a high barometer the movement is inward, while when the air is light during a low barometer it is outward. Since the well and weather phenomena correlate so closely the wells are called weather wells, and the changes in atmospheric pressure are supposed to cause the "blowing." The dry gravel below forms a reservoir into and out of which air readily passes. While there is more or less air in all formations, that in the porous beds moves most freely. Naturally this reservoir of air is affected by pressure, and the well is an artificial connection between the atmosphere and the air in the porous beds below. Inhalation during very cold weather causes the pipes to freeze sometimes as far down as the water. As soon as a reverse movement begins the pipes thaw out rapidly.

Mr. Charles C. Cleveland, of Creighton, Nebr., furnishes the following description of his well:

My well is 3 feet in diameter and 165 feet deep, dug through loess, 80 feet; sand and gravel, 65 feet; clay, 20 feet. From this clay a 2-inch hole was bored down to water gravel from which the water flowed 15 feet deep in the 3-foot hole. In this well there is at times a current of air moving in or out, although

during much of the time it is entirely still. When the weather moderates in winter or is getting warmer at any time the well blows, and the air hissing through the platform can be heard rods away. When the weather turns cold, the air is sucked in. This air must have come out of the dry gravel below the loess. The pump platform has to be made air-tight in winter to prevent pipes freezing to the bottom of the well. All deep wells in this vicinity are blowing wells.

### POLLUTION OF WELL WATERS.

Water is rendered impure by the presence of mineral and organic matter. Some kinds of these may be present without affecting the desirableness of the water for drinking and domestic purposes, but most impurities either are, or are likely to become, injurious to the health. The water supply which comes principally from shallow wells and springs often become contaminated from the surface and is then a source of contagion. Many cases of typhoid fever have come from this cause. The site for a dug well should be selected with great care and should be as far as possible from barnyards, backhouses, etc. All surface drainage should be kept away. Placing a well on higher ground than the house and outbuildings is not always a safeguard, for the water level in a well is so low that in some cases there may be a direct underground seepage from a dangerous source of contamination. Wood curbing often fouls the water by rotting. Spring water may also become polluted if it flows from sands not well protected from surface contamination.

## WATER RESOURCES BY COUNTIES.

### NORTHERN PART OF HOLT COUNTY.

*Topography.*—The northern part of Holt County drains northeastward to Niobrara River. It is a thinly settled region of over 900 square miles, in which stock raising and dairying are the principal industrial pursuits, especially where the land is rough or sandy. There is considerable farming on the table-land just north of Stewart, Atkinson, and O'Neill. North of this table-land the slope to the Niobrara is quite perceptible, as there is a fall of 400 to 500 feet in from 15 to 25 miles. Tertiary sands form the broad surface slopes. A sand-hill area 5 to 8 miles wide, but with indefinite boundaries, lies just south of Niobrara River and extends across the northern part of the county. The surface sands and gravels here were derived in part from the Tertiary sands and in part from materials brought into the region by Niobrara River when it flowed at a higher level. Beneath the sandy formations the whole region is underlain by Pierre clay, which comes to the surface along the Niobrara and along the lower courses of the principal creeks, forming steep slopes.

The main stream is Niobrara River. Its principal tributaries in this county are the Redbird, Eagle, Big Sandy, and Beaver creeks,

all of which head in the table-land and flow northeastward to the river. They are fed principally by springs and flow all the year, the run-off not being much affected by the average rain or by dry weather. The streams vary in length from about 15 to 30 miles, and the grade varies but is generally steep. The valleys are narrow and semicylindrical in form at the edge of the table-land, wider and more mature across the Tertiary slopes, and more deeply trenched in the outcrop zone of Pierre clay. The stream water is used principally for stock and to some extent for domestic purposes.

*Water power.*—None of the creeks have been gaged, but it is evident that they would afford much water power, and the conditions are such that power could be easily and cheaply developed. There are favorable places for inexpensive dams along all of the creeks, while on some of the principal creeks there are numerous power sites. At Turner, Mr. William Knollkemper has a dam (see Pl. VII, *B*, p. 18) 150 feet long and 8 to 10 feet high, constructed of brush, clay, and manure. The power is used to run a well-equipped flouring mill, with a capacity of 60 barrels a day, which has been in operation for twenty-five years. The dam cost but little, for it is simply a crude breakwater which diverts part of the stream into a mill race. For several years a mill was operated on the Big Sandy, near Badger, but it was recently moved to Butte, Boyd County. The dam and race have been somewhat improved and power will be transmitted to the mill at Butte, a distance of 7 miles.

The main drawback to the development of water power for mill purposes in the northern part of Holt County is in the lack of shipping facilities for mill products. However, cheap power could be developed and transmitted to railroad towns both north and south. This plan ought to prove feasible, as fuel for power is high priced.

*Springs.*—Springs from Tertiary and terrace sands and gravels lying on the impervious Pierre clay are numerous along all of the creeks. They afford a large supply of good drinking water, and are used for domestic purposes, stock water, and for irrigation when needed. About Ray they are found on many farms and occur numerously about Saratoga on a small tributary of Eagle Creek. Above Turner on sec. 26, T. 32, R. 11 W. the John Donlin Springs seep out of the sands. Little Sandy Creek heads at a large spring. Near Phoenix some heavy springs are used to irrigate a large orchard, and 5 miles west of Badger some strong springs are used for irrigation during dry years. The Mullehan Springs near Paddock are well known; the water comes out of sand and gravel above the Pierre clay, forming a small fall 35 feet high. In this vicinity there are several very strong springs, most of which are not used. Near the mouth of Eagle Creek springs supply large fish ponds and in dry seasons irri-

gate from 15 to 20 acres of orchard and garden. At another ranch 2 miles east the spring water, conducted by a ditch three-fourths mile long, is used for irrigation purposes. The springs of this county could be used to greater advantage than they are at present, for in most cases they are high on the slopes and might be piped to and through the houses, which are generally located in the valleys below. Also it seems probable that by boring or by tunneling the ground water at boggy places not far below the table-land could be tapped and caused to flow out as strong springs.

*Shallow wells.*—Since settlements usually begin along the streams or at springs, few wells were put down until the country back from the natural water supply began to be used, first for grazing and later for farming. In much of the higher area of the county sandy formations yield a suitable supply of water, usually soft. At a few places, as north of Middle Branch, the water is in fine sand and is difficult to strain. There are several blowing wells in the vicinity of Mineola.

The following table will serve to show the different well-water conditions:

*Representative wells of northern Holt County, Nebr.*

| Owner. | Location. | Depth. | Diameter. | Depth of water. | Remarks. |
|---|---|---|---|---|---|
| | | *Feet.* | *Inches.* | *Feet.* | |
| O'Neill | O'Neill | 1,400 | (a) | 1,360 | Some bad water. Failure. Cost $3,000. |
| J. M. Packard | Sec. 12, T. 29 N., R. 9 W. | 160 | 2 | ..... | Sand all the way down, on high ground. Uses Cook strainer. |
| E. H. Lees | Sec. 28, T. 31, R. 10 W. | 60 | 8 | 10 | On high ground. Through 57 feet of sand into gravel. |
| H. R. Henry | Sec. 22, T. 30, R. 10 W. | 68 | 10 | 9 | Through sand and gravel to coarse gravel. Blowing well. High ground. |
| George Tomlison | Sec. 25, T. 31, R. 10 W. | 76 | 8 | 12 | High ground. |
| A. B. Powell | Sec. 3, T. 31, R. 10 W. | 80 | 8 | 8 or 9 | Do. |
| A. L. Wilcox | Sec. 18, T. 31, R. 12 W. | 16 | 42 | 4 or 5 | In valley. |
| Mr. McGowen | Sec. 24, T. 31, R. 12 W. | 365 | ..... | ..... | Through sand and gravel 15 feet into Pierre clay. On Red Bird divide. |
| Henry Lasher | Sec. 24, T. 31, R. 12 W. | 120 | 8 | 14 | Log: Clay and sand, 25 feet; clay, 20 feet; hard sandy layer, 1 foot; soft decomposed layer; sand. |
| J. J. Schwetzer | Sec. 36, T. 31, R. 12 W. | 8 | 36 | ..... | Dug well. In valley. |
| A. Dobson | Sec. 12, T. 33, R. 12 W. | 20 | ..... | 12 | In valley. |
| J. F. Green | Sec. 9, T. 33, R. 14 W. | 18 | 12 | 8 | Water in pure white sand just above Pierre clay. |
| Frank Sanders | Sec. 12, T. 33, R. 15 W. | 20 | 10 | 10 | Abundant supply. |
| William Dusten | Sec. 22, T. 33, R. 15 W. | 90 | 12 | ..... | |
| Winslow Bros | Sec. 14 T. 33, R. 14 W. | 28 | 5 | 10 | Easily lowered Through soil, sand, gravel. |
| A. W. Sexton | Sec. 33, T. 34, R. 14 W. | 26 | 12 | 13 | Easily lowered. |

(a) Reduced three times; 2 inches at bottom.

*Artesian water.*—There are no deep artesian wells in this county, but many shallow flowing wells are found in the southern townships south of the area treated in this report.

The deep flow reached at a depth of 923 feet in the new well at Lynch, Boyd County, should, if tapped at Whiting bridge, have

pressure sufficient to raise the water 75 feet or more above the river. According to barometric readings this would lack about 45 or 50 feet of reaching the river level at the Badger bridge. But since there is a gradual increase in pressure to the west, it is quite probable that a fair flow could be obtained at Badger at a depth of somewhat over 1,100 feet, and on the same basis it appears likely that the water would rise to the river level as far west as the mouth of the Keyapaha River and probably farther.

### BOYD COUNTY.

The water conditions in Boyd County present considerable variety, owing to the diversity of the geologic formations. These comprise surface alluvial deposits, Tertiary sands, Pierre clay, and the Niobrara chalk rock.

*Streams.*—Missouri River receives several unimportant tributaries in the northeastern part of the county, draining an area of approximately 50 square miles of hilly country. The Niobrara flows with steep grade along the southern border of the county, draining a narrow district of approximately 125 square miles and a much larger area in Holt County. This water is used for stock and to some extent for domestic purposes, especially where a suitable supply can not be had from springs and wells. Keyapaha River, a tributary of the Niobrara, flows through a grazing country and is an important source of stock water. The conditions along this stream are favorable for small power sites. Ponca Creek, though having but a weak flow, drains more than half of the county. Its lower course is quickly affected by storm water, owing to extensive slopes of gumbo, or Pierre clay. It heads in broad, shallow sloughs in Gregory County, S. Dak., and in the high lands of Boyd County receives small amounts of ground water and a limited supply from direct run-off. Between Spencer and Butte there are successive terraces at rather regular intervals along the valley, which afford a good supply of spring and well water. Here many of the weak tributaries begin in elliptical holes and ponds in shallow sloughs. Ponca Creek affords good stock water. It has been used successfully as a source of mill power.

*Springs.*—The source of spring water here, as in Holt County, is the ground water in the Tertiary and terrace sands and gravels. Springs occur in large numbers; for example, on the SE. ¼ sec. 8, T. 34, R. 16 W., there are 25 springs, and on sec. 5, adjoining, a shallow cut developed a supply of water that flowed a distance of 120 rods.

The supply of water for Spencer is obtained from springs which come out of terrace sands and gravel three-fourths of a mile northwest of the town. The water is collected in a reservoir at the highest possible level and then pumped to a standpipe. Spring water is piped

into a house in Lynch. All along Ponca Creek above Bristow springs issue from sand just above clay, and similar conditions exist along all of the principal streams of the county, especially the Keyapaha in the region of Twin Buttes.

*Shallow wells.*—The well-water supply of Boyd County has been reported as limited and bad, but, while it is true that some farmers have to haul water and that certain small towns have a poor supply, such cases are exceptional. Much alkali water is found in Pierre clay areas, but a large amount of soft water is obtained from Tertiary sand. Many of the gravels yield hard water, and the supply from the chalk rock seldom is satisfactory. Since the central and eastern parts of the county present a variety of surface formations, there are frequent differences in the quality of the underground water. In the area of Pierre shale, where the soil often is satisfactory for crop raising, the water is nearly always bad, but ordinarily it is practicable to locate the farm house on some other formation which will yield good well water. In locating wells it is advisable to prospect in sandy soil with small augers, and in sinking it is best to stop as soon as gumbo is reached, unless a cemented reservoir is to be constructed, for the alkali is dissolved from the clay by the water while it stands in the well. It has been observed that heavy pumping improves the quality of water in wells sunk through sand into the clay. Dry wells are not numerous and probably they occur only where the surface of the impervious clay rises above the ground-water level. Ordinarily such areas are of small extent, and trial borings will indicate their limits.

At Butte good and bad waters occur within a few rods. The water-bearing sands lie in depressions and yield a suitable and an abundant supply. In intervening areas the wells extend into gumbo and yield scanty supplies of poor water. If necessary an abundance of desirable water can be piped from wells near the buttes just south of town. At Monowi the wells are not favorably located, and the result is unsatisfactory. The supply at Gross is usually good.

*Representative shallow wells of Boyd County, Nebr.*

| Owner. | Location. | Depth. | Diameter. | Depth of water. | Quality. | Remarks. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Inches.* | *Feet.* | | |
| Hamilton place | Sec. 36, T. 32, N. R. 9 W. | 22 | 20 | 9 | Soft | |
| Chris Johnson | Sec. 24, T. 32, R. 10 | 25 | 18 | 5 | Bad | Limited supply. Soil, sand, gravel, Pierre clay. |
| Charles W. Orr | Sec. 33, T. 34, R. 10 | 15 | 36 | 4 | Hard, good | |
| C. C. Irwin | Sec. 14, T. 33, R. 10 | 24 | 16 | 9 | do | Soil, sand, gravel. |
| J. C. Hoffman | Sec. 14, T. 33, R. 10 | 21 | 36 | 3 | do | Sand and gravel. |
| Hubert Van Pelt | Sec. 14, T. 33, R. 10 | 22 | 12 | 5 | do | Soil, sand, gravel. Limited supply. |
| B. Baker | Sec. 2, T. 32, R. 10 | 12 | 60 | 6 | Hard, fair | Soil, weathered Pierre clay. |
| Albert Gillman | Sec. 2, T. 33, R. 10 | 22 | 36 | 10 | Hard, poor | Soil, sand, weathered Pierre clay. Limited supply. |
| F. P. Mark | Sec. 34, T. 34, R. 10 | 24 | 24 | 16 | Medium hard, good | Sandy loam, clay, sand. |
| John W. Orr | Sec. 21, T. 34, R. 10 | 30 | 24 | 8 | do | Soil, clay, native lime, sand, and gravel. |
| C. A. Dean | Sec. 19, T. 34, R. 10 | 89 | 18 | 10 | do | Soil, sand, clay, sand. |
| F. M. Stumbo | Sec. 20, T. 34, R. 10 | 44 | 28 | 16 | Soft good | Water in 16 feet of gravel under 24 feet of Tertiary marl. |
| P. Carroll | Sec. 29, T. 34, R. 10 | 22 | 12 | 12 | Hard, good | |
| Joseph Crowe | Sec. 22, T. 34, R. 10 | 16 | 36 | 4½ | Soft, fair | |
| I. Jonason | Sec. 25, T. 33, R. 11 | 48 | 36 | 3½ | Soft, good | Water in sand. |
| W. T. Reshaw | Sec. 18, T. 33, R. 11 | 66 | 24 | 7 | Medium hard | Very cold water in thin bed of sand. |
| A. Fulckrod | Sec. 9, T. 33, R. 11 | 11 | 36 | 6 | Poor | |
| Wm. Seeley | Sec. 18, T. 33, R. 11 | 66 | 24 | 6 | Alkaline, bad | Soil, Pierre clay. |
| Martin Laugon | Sec. 19, T. 33, R. 11 | 36 | 4 | 13 | Medium hard, fair | |
| Henry Wagoner | Sec. 28, T. 34, R. 11 | 33 | 36 | 10 | Soft, good | |
| W. J. Everett | Sec. 2, T. 35, R. 11 | 32 | 24 | 6 | Soft | Water in gravel under 21 feet of sand. |
| W. T. Reshaw | Sec. 35, T. 33, R. 12 | 30 | 16 | 15 | Medium hard, bad | Poor water; not used; in Pierre. |
| L. S. Anger | Sec. 34, T. 34, R. 12 | 45 | 12 | 4 | Soft | Soil, sand and gravel. |
| M. Coleman | SE. ¼ sec. 35, T. 33, R. 12 | 24 | 36 | 12 | do | Soil, sand, and thick white chalk. |
| W. E. Kloke | NE. ¼ sec. 35, T. 33, R. 12 | 21 | 12 | 9 | do | Soil, hard-pan soil, putty rock 8-9 inches; gravel, 1 foot; quicksand, 6 feet. |
| I. N. Morrison | NW. ¼ sec. 10, T. 34, R. 12 | 13 | 36 | 8 | Medium | Soil and sand. |
| J. D. Schmidt | Sec. 22, T. 33, R. 12 | 32 | 12 | 8 | Soft | Soil, sand, and gravel. Just to Pierre. |
| S. C. Claucus | Sec. 6, T. 33, R. 12 | 18 | 13 | 10 | do | Soil, sand, and gravel. |
| W. S. Eaton | SE. ¼ sec. 30, T. 34, R. 12 | 41 | 26 | 6 | do | Black soil, 3-4 feet; sand and gravel, 5-6 feet; clear sand, quicksand. |
| John Lampman | NW. ¼ sec. 31, T. 34, R. 12 | 32 | 38 | 8½ | Hard | Soil, sand, white chalky clay. |
| O. R. Carmidrall | SW. ¼ sec. 31, T. 34, R. 13 | 75 | 15 | 15 | do | Clay, rest magnesia. Some gravel in bottom. |
| A. D. Prattyman | NW. ¼ sec. 6, T. 33, R. 13 | 70 | 36 | 12 | Soft | Soil and clay subsoil (light). Did not reach soapstone. |
| J. P. Ross | Sec. 24, T. 33, R. 13 | 36 | 10 | 9 | Hard | Soil, sand, and gravel. Water in gravel. |
| C. E. Whittig | NW. ¼ sec. 15, T. 34, R. 13 | 32 | 16 | 10 | do | Clay, gravel, and quicksand. |
| Elrich Windmyer | SE. ¼ sec. 21, T. 34, R. 13 | 50 | 18 | 25 | Soft | Soil, light-colored, sandy clay. Did not reach soapstone. |
| John Webber | Sec. 36, T. 33, R. 13 | 10 | 48 | 5 | do | Soil and sand. |
| J. D. Garmley | NW. ¼ sec. 29, T. 34, R. 13 | 33 | 36 | 10 | do | Soil, 5 feet; sand, 12 feet; magnesian clay, 20 feet; sand and gravel. |
| J. Gamley | Sec. 25, T. 34, R. 14 | 43 | 48 | 16 | do | Soil and loam, 10 feet; clay, 30 feet; sand and gravel. |
| G. S. Wright | NE. ¼ sec. 21, T. 34, R. 14 | 32 | 22 | 16 | Medium hard | Soil, clay, subsoil, sand. |
| Ed McKemper | Sec. 30, T. 35, R. 16 | 125 | 12 | 15 | Soft | Water in 14 feet; sand and gravel under 110 feet of Tertiary marls and sands. |
| Dwight E. Brown | SE. ¼ sec. 8, T. 34, R. 16 | 33 | 16 | 10 | do | Soil and clay. |
| Jacob Heimerdinger | SW. ¼ sec. 11, T. 34, R. 16 | 15 | 48 | 10 | Hard, good | Clay, 4 feet; balance in a flinty rock. |

*Artesian wells.*—All of Boyd County is underlain by Dakota sandstone containing artesian water, but only a limited area is low enough for surface flows. Strong wells can be obtained along the Missouri bottom and along the Ponca Valley at least as far west as Spencer. The heavy pressure in the deep well recently finished at Lynch demonstrates that there is a deeper and stronger flow there, and probably that artesian wells can be had farther up Ponca Creek and Niobrara River than was formerly supposed. A deep flow was reached at Lynch, which has sufficient pressure to raise water to an altitude of 1,590 feet. This indicates that a surface flow can be obtained in the valley below Spencer, at a depth of about 1,065 feet. If the pressure increases westward across Boyd County a flow may be had in the valley below Anoka at a depth of about 1,170 feet, and as far west along the Niobrara bottom as the Badger Bridge and probably farther. Wells far to the west are more expensive to bore on account of increased depth and will afford little water power.

The wells at Lynch throw much light on the underground conditions. In the old well, completed in 1900, it is reported that at the top there were 260 feet, mostly "soapstone," 40 feet of Niobrara chalk rock at the base of the Niobrara formation, 275 feet of "soapstone" with some hard layers, 25 feet of hard rock and "sandstone" (presumably Greenhorn limestone), 20 feet of soapstone and clay, 50 feet of slate with coaly layers, 4 feet of so-called coal, 38 feet of sandstone, 30 feet of hard clay and sandstone, and 18 feet of porous sandstone in which the flow began. Other flows appeared in sandstones below until, at 797 feet, the flow was so strong that work was discontinued. The flow was 465 gallons a minute, pressure 52 pounds, temperature 79½° F., and diameter 6 to 4½ inches. In the new well bored in 1903 a pressure of 85 pounds is reported and a yield of 3,100 gallons a minute. The large flow in the new well is somewhat spasmodic in pressure and it has also thrown out considerable sand. It is to be used for mill power. The first flow was at 740 feet and the third at 875 feet; the temperature is 90°, and the diameter is 10 inches to 350 feet and 8 inches below. This well is shown in Pl. X.

*Section of the new artesian well at Lynch, Boyd County, Nebr.*

| | Feet. |
|---|---|
| Sand and gravel | 0– 18 |
| Pierre clay (called soapstone) | 18–105 |
| Niobrara chalk rock, sandy and hard below | 105–300 |
| Carlile clays, with some beds of pyrites | 300–588 |
| Greenhorn limestone | 588–610 |
| Graneros clays and shales | 610–700 |
| Dakota sandstone and clay, alternating. Four or five different flows reported | 700–923 |

Total depth 923 feet. Altitude of mouth, 1,392 feet.

SECOND ARTESIAN WELL AT LYNCH, NEBR.

*Analyses of waters of artesian wells at Lynch, Nebr.*[a]

[Parts per million.]

| | 8-inch or new well. | 4-inch or old well. |
|---|---|---|
| Combined water and organic matter | 233 | 232 |
| Silica ($SiO_2$) | 56 | 16 |
| Iron and alumina ($Fe_2O_3$ and $Al_2O_3$) | 10 | 2.8 |
| Calcium (Ca) | 251 | 255 |
| Magnesium (Mg) | 39 | 57 |
| Sodium (Na) | 46 | 52 |
| Potassium (K) | 12 | 15 |
| Sulphate radicle ($SO_4$) | 682 | 667 |
| Carbonate radicle ($CO_3$) | 75 | 67 |
| Chlorine (Cl) | 74 | 61 |
| Total solids | 1,474 | 144 |

[a] S. Avery and A. Jacobsen, analysts.

A well is now (1905) being drilled on sec. 33, T. 34, R. 11, near Rosedale, but the drill is fast at a depth of 793 feet. If boring is continued, a good well may be obtained at a depth of 1,100 to 1,200 feet. The first mill well at Lynch was three years in boring. The following altitudes, obtained from the Chicago and Northwestern Railway and by the use of an aneroid barometer, may be of value in considering the depth and head of the artesian waters:

*Altitudes on line of Chicago and Northwestern Railway.*

| | Feet. |
|---|---|
| Monowi [a] | 1,322½ |
| Lynch [a] | 1,400½ |
| Spencer [a] | 1,541½ |
| Anoka [a] | 1,638½ |
| Fairfax, S. Dak.[a] | 1,932½ |
| Niobrara River at Whiting Bridge | 1,502 |
| Niobrara River at Badger Bridge | 1,635 |
| Missouri River at Greenwood | 1,229 |
| Missouri River at Fort Randall | 1,240 |
| Town of Spencer | 1,637 |
| Town of Butte | 1,795 |

## KNOX COUNTY.

Loess, varying in thickness from a few feet to over 100 feet, forms the surface over most of Knox County, its continuity being interrupted by a sandy area west of Verdigris Creek, by a clayey region beyond the Niobrara, by sandy sections near Santee, and by places where deeper valleys cut through to underlying formations. The northern and central parts of the county are somewhat hilly, and lower than the more level regions to the south and southeast. There is considerable bottom land along the Missouri and the Niobrara. The chalk rock so prominently exposed along the Missouri extends southward under the Pierre, Tertiary, Glacial, and loess deposits.

[a] Base of rail at station.

In much of the county the Pierre clay and Niobrara chalk rock, which usually afford an inferior supply of water, are deeply buried by other formations and are not reached in ordinary wells. Except for an area of about 60 square miles draining south to Elkhorn River, the general slope and drainage is northward to the Missouri.

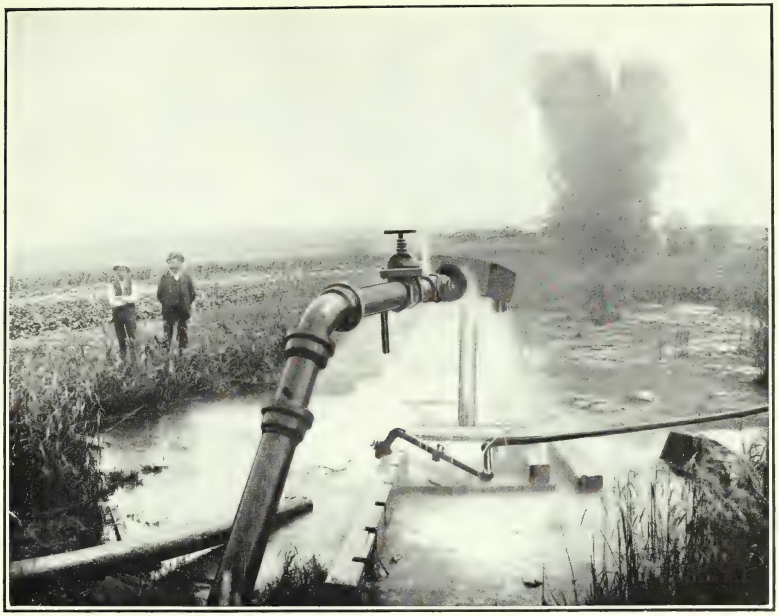
*Streams and water power.*—The Missouri is the most important stream; it flows along the northern margin of the county and is often the source of local water supply. The Niobrara River receives 7 tributaries of some importance from the south, but practically none from the north. Verdigris Creek, with a drainage basin of about 250 square miles, is one of the best water-power streams in northern Nebraska, gaging about 105 second-feet and flowing throughout the year. A mill is successfully run by water power from this stream at the town of Verdigre; the dam is constructed of greenish quartzite obtained 6 or 7 miles southwest. Several other good power sites exist between Verdigre and Niobrara River.

Bazile Creek closely resembles the Verdigris in character, but has a drainage basin in the center of the county, of about 400 square miles in area. Much of the power here is not favorably located with respect to railroads, but it might be transmitted to Creighton, Bloomfield, Winnetoon, and other towns. There are two well-constructed dams along the creek, one at the Bazile mill and the other at the lower Bazile mill (see Pl. XI, *B*). Each dam has a fall of about 12 feet and is made of greenish quartzite and each supplies water for 60-barrel flouring mill. Farther downstream numerous favorable power sites could be located.

Frankforter Creek, frequently called Weigand Creek, in the northeastern part of the county, is too weak for power, especially during the drier months.

*Springs.*—The rainfall accumulates as ground water in the loess and sand and gravel deposits, and from these springs issue, especially at the contact with impervious beds. Many flow from the outcropping edge of the top of the Pierre clay, which extends along the sides of the valley slopes. Talus from later formations often covers the clay more or less in the outcrops and sometimes carries the spring water to lower levels. In some parts of the county the upper surface of the clay is very uneven as a result of erosion.

As in adjacent counties the number of springs is very great, practically every little ravine along the Niobrara, Verdigris, and Bazile valleys being fed by a spring, large or small. Only a few can be noted: Springs just southwest and northwest of Verdigre could be piped to furnish an abundance of water for the town. The La Mont Springs, about 2 miles south of Niobrara, are quite strong. A spring at the place of R. F. Stout, sec. 5, T. 30, R. 5 W., south of Center, is



*A.* OLD WELL AT SANTEE AGENCY, NEBR.

*B.* LOWER DAM ON BAZILE CREEK, KNOX COUNTY, NEBR. BUILT OF QUARTZITE.

piped some 350 yards to a hydrant at the house; the water, temperature 55½° F., issues from the base of coarse sand at the clay contact, at an altitude of about 1,525 feet, or 35 feet above the hydrant. A notably heavy spring is located 1½ miles southeast of Center. A small spring near the creek at the lower Bazile mill yields a good quality of drinking water; the flow is 7 gallons per minute, and the temperature 54½°. Several springs are found along the Frankforter Creek; one at Weigand affords a good supply of water for a public watering place, stock, and house use.

*Shallow wells.*—North of Niobrara and in the Ponca basin the shallow-water conditions are very variable; the best supplies are obtained from irregular areas of sand and gravel on the divides and from the flood-plain deposits. In the southwestern part of the county water is derived from Tertiary sands in wells from 100 to 200 feet deep. In the central, southern, and eastern portions good water is obtained in gravel, which often lies 175 feet deep on high ridges and table lands, and 20 to 35 feet in the old northwest-southeast valley extending from Verdigris Creek past Winnetoon and Creighton to the southeast. At a few places Tertiary sands rise above the gravel beds and afford a supply at less depths. Many blowing wells are found in Tps. 29 and 30, Rs. 2, 3, and 4.

The Pierre clay has not been reached in wells over 200 feet deep on the high lands south of Bloomfield, which indicates a great thickness of post-Cretaceous formations, many of them water-bearing. Over much of the eastern half of the county two gravel beds, separated by clay and sand, are encountered, except where they have been removed by erosion or where Tertiary sands rise above them.

In this county, as elsewhere, the water derived from wells extending into the Pierre clay and the Niobrara chalk rock usually contains much alkali, unless the beds have lost their soluble matter by leaching. Usually, not far from places underlain by these formations, good water may be obtained from alluvial or other sands.

*Artesian wells.*—Large supplies of artesian waters are available in all of the lower lands of the county, and in many places the conditions are favorable for high-pressure wells. The mill well at Niobrara, used so successfully for power, indicates that such wells might be obtained at many points on the Missouri, Niobrara, and Ponca bottoms. With little doubt one or more stronger flows can be had at a slightly greater depth, and an attempt is now being made at the Niobrara mill to reach one of these; the last report (1905) indicates slow progress in the drilling and a depth of 500 feet.

*Representative shallow wells of Knox County, Nebr.*

| Owner. | Location. | Depth. | Diameter. | Depth of water. | Quality. | Remarks. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Inches.* | *Feet.* | | |
| Charles Cleveland | Sec. 28, T. 29 N., R. 4 W | 186 | 4 | 36 | | Clay, 80 feet; gravel and sand, 65 feet; clay, 40 feet; gravel, 1 foot. |
| Jack L. Burt | Sec. 23, T. 29, R. 4 | 185 | 3 | 4 | Soft | Yellow clay, 80 feet; sand, 60 feet; dry quicksand, 23 feet; dry gravel, 13 feet; hard pan, 4 feet; gravel, 4 feet. |
| D. C. Billeck | Sec. 26, T. 29, R. 4 | 182 | 2 | 10 | | Loess, 120 feet; sand, 18 feet; dry gravel, 24 feet; yellow clay, 8 feet; water gravel, 8 feet. |
| W. H. Wort | Sec. 26, T. 29, R. 5 | 40 | 12 | 10 | Soft | 25 to 28 feet sandy loam; sand, quicksand, gravel. |
| (In town) | Sec. 3, T. 30, R. 3 | 20 | 2 | 4 | | |
| Colin Valentine | Sec. 11, T. 30, R. 3 | 40 | 30 | 32 | Soft | |
| Peter Ward | Sec. 1, T. 30, R. 4 | 126 | | 2 | .....do | Blue clay—some sand and gravel. |
| John Roberts | Sec. 3, T. 30, R. 4 | 90 | | Dry. | | 15 feet of black soil and rest mostly sand; coarse gravel in bottom. |
| John Tucker | Sec. 3, T. 30, R. 4 | 137 | | | Hard | Black soil and sand with some clay. |
| John Roberts | Sec. 4, T. 30, R. 4 | 169 | | Varies. | .....do | 50 feet black soil and rest dry sand; water easily lowered, but quite steady supply. |
| Louis Eggert | Sec. 8, T. 30, R. 4 | 102 | | 2 | .....do | Black soil on top, sand and gravel below. |
| Charles Ward | Sec. 9, T. 30 R. 4 | 140 | | 12 | .....do | Sand and gravel, little clay; water supply not steady; easily lowered at times. |
| I. Ellingson | Sec. 4, T. 30, R. 5 | 16 | | 9 | | Sand and gravel; well in bottom above creek. |
| W. D. Patton | Sec. 35, T. 31, R. 3 | 14 | 3×4 | 3 | | |
| J. B. Crockett | NE. ¼ sec. 21, T. 31, R. 4 | 57 | | 15 | Hard | Soil, bluish clay, gravel and water. Blowing well. |
| Frank Hajek | Sec. 8, T. 31, R. 5 | 30 | 16 | 6 | Soft | Soil, sand to soapstone. |
| Frank Jelenek | Sec. 5, T. 31, R. 5 (in town) | 17 | 12 | 3 | .....do | Soil, sand and water in gravel. |
| F. P. Krolop | NW. ¼ sec 12, T. 32, R. 8 | 18 | 18 | 10 | Medium | Soil, sand, 2 feet; gravel, 2 feet; soapstone rest of distance. |
| Chris. Johnson | Sec. 28, T. 32, R. 8 | 8 | 36 | 4 | .....do | Soil, 4 feet; sand, sand and gravel. |
| J. H. Rothwell | Sec. 25, T. 32, R. 8 | 35 | 1½ | 10 | Hard | Soil; reddish clay, 25 feet; gravel. |
| M. Thompson | Sec. 18, T. 32, R. 6 | 21 | 2 | 10 | Soft | Soil and sand. In Niobrara Valley. |
| J. A. Lindsan | Sec. 16, T. 32, R. 6 | 14 | 2 | 3 | .....do | Black soil, 5 feet; sand, 9 feet. |
| L. Weigand | Sec. 1, T. 32, R. 3 | 24 | 24 | 10 | .....do | Soil, clay, then water. |
| C. H. Sawyer | NE. ¼ sec. 7, T. 32, R. 3 | 40 | 36 | 9 | Medium | Soil, loess, 35; sand and gravel with water. |
| Frank Weigand | NE. ¼ sec. 10, T. 32, R. 3 | 42 | 24 | 8 | .....do | Soil, loess 6; sand and gravel. |
| Chas. Jancore | Sec. 7, T. 32, R. 3 | 125 | 24 | | | |
| James Renner | W. ½ sec. 23, T. 32, R. 3 | 24 | 36 | 15 | Hard | Soil, sand and gravel. In small valley. |
| School | Sec. 13, T. 33, R. 5 | 80 | | 6 | Alkaline | 6 feet into chalk rock. |
| Charles Jacocks | Sec. 11, T. 32, R. 3 W | 130 | 36 | 5 | Hard | Soil, loess and sand (?). |
| D. C. Cleveland | 5½ miles east of Creighton | | | | | Sandy loess, 75; gravel, 80; fine sand, 10. |

A new well is soon to be put down at the Santee Agency. The old well there, which has been used successfully for mill power, irrigation, fire protection, and general water supply, is now of little use (see Pl. XI, *A*), because the casing has rusted off 2 or 3 feet below ground. The large well at the school afforded clear water for about two weeks when finished, and the volume was at first over 2,000 gallons per minute. After a while it began throwing out sand and shale, and the flow ceased entirely a few times but was started again each time by cleaning. At present the pressure is 26½ pounds at the mouth of the well, which is 105 feet above Missouri River. In this well trouble was experienced with the casing at a depth of about 500 feet. The present water supply is thought to come principally from the first flow. Wells in the northeastern part of the county have decreased in pressure and flow, principally because they were not properly cased.

Attempts to get wells on high lands have failed because of the altitude, the pressure, though strong in the water-bearing beds below, not being sufficient to force the water to the height necessary.

*Record of well at the packing house, Niobrara, on the Missouri bottom, sec. 8, T. 32, R. 6 W.*

| | Feet. |
|---|---|
| Soil and sand | 0– 70 |
| Niobrara chalk rock | 70–200 |
| Clays and shales with thin beds of iron pyrites (Carlile) | 200–410 |
| Limestone (Greenhorn) | 410–442 |
| Clay and shale (Graneros) | 442–520 |
| Dakota sandstone and clay | 520–600 |

*Record of small well at the school, Santee, Nebr., sec. 13, T. 33, R. 5 W.*

[Mouth of well 143 feet above the Missouri River.]

| | Feet. |
|---|---|
| Soil and sand | 0 – 23 |
| Pierre clay | 23 – 35 |
| Niobrara chalk rock | 35 –240 |
| Clay, shale, and thin beds of iron pyrites (Carlile) | 240 –445½ |
| Limestone (Greenhorn) | 445½–502 |
| Clay and shale (Graneros) | 502 –600 |
| Dakota sandstone | 600 –604 |

*Record of John Lytle well, sec. 19, T. 33, R. 2 W., Nebraska.*

[Mouth about 70 feet above the Missouri River.]

| | Feet. |
|---|---|
| Soil | 0– 6 |
| Niobrara chalk rock | 6– 88 |
| Clays and shales with hard beds (Carlile) | 88–380 |
| Limestone (Greenhorn) | 380–400 |
| Clay and some shale (Graneros) | 400–490 |
| Dakota sandstone and clay (second flow) | 490–530 |

| Name. | Location. | Diameter. | Depth. | When drilled. | Pressure when drilled. | Yield per minute. | Temperature. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| | | *Inches.* | *Feet.* | | *Pounds.* | *Gallons.* | *F.°* | |
| Dan's well, Hiles ranch. | 1¼ miles east of Monowi, sec. 18, T. 33, R. 8 W. | 3-2 | 770 | 1895 | ..... | ..... | 70 | Pressure now 11 pounds, with leak. Third flow, 740 feet. Temperature varies. |
| O. Hegen..... | 7 miles west of Niobrara, sec. 21, T. 32, R. 7 W. | 2 | 500 | 1903 | ..... | ..... | ..... | A surface flow is not expected. Depth given is for Aug. 15, 1903. |
| Mrs. John Havlicek.. | Near Verdigris, sec. 29, T. 31, R. 6. W. | 2 | 770 | 1896 | Formerly 34, now 11. | 14 now..... | 74½ | |
| Niobrara mill well... | Niobrara..... | 8 | 656 | 1896 | At first 95..... | 1,900..... | 68 | Pressure July 14, 1903, 65 pounds when not entirely shut off. Pressure 120 pounds when closed 2 weeks in 1896. |
| Niobrara packing-house well. | .....do..... | 2 | 600 | 1895 | Reported 107..... | Was 280..... | 66 | Pressure weak now with leak; also yields about 35 gallons per minute. |
| Foreman ranch..... | 4 miles east of Niobrara, sec. 12. T. 32, R. 6 W. | 2 | 548 | 1903 | 82..... | 240..... | 65 | Principal flow at 520 feet. |
| Large school well.... | Santee, sec. 13, T. 33, R. 5 W. | 8 | 740 | 1899 | 55 when drilled, 26⅔ now. | 1,699 when drilled, 106.2 cubic feet now. | 64 | Mouth of well 105 feet above Missouri River. |
| Small school well.... | .....do..... | 3 | 604 | 1885 | Very weak..... | ..... | 64½ | This water is piped through houses. |
| Agency well..... | .....do..... | 6 | 600 | ..... | Weak..... | ..... | 64 | Not much used now. Leaks at break in pipe. |
| Herrick ranch well... | 2 miles west of Herrick, sec. 16, T. 33, R. 3 W. | 2 | 400 | ..... | Was strong, weak now. | 8..... | 62 | Pipe badly rusted. On Missouri bottom. |
| Clark well (formerly Brown). | 1½ miles northwest of Herrick, sec. 15, T. 33, R. 3 W. | 2 | 400 | ..... | Weak..... | ..... | 61 | On bottom land. Cased the second time. |
| T. C. Van Meter..... | Sec. 13, T. 33, R. 3 W ... | 2 | 504 | 1892 | Not strong..... | 2..... | 63 | On high ground. |
| John Lytle..... | Sec. 19, T. 33, R. 2 W ... | 2 | 550 | 1899 | ..... | 10..... | 63½ | About 70 feet above the Missouri River. |
| C. D. Buhrow..... | Sec. 20, T. 33, R. 2 W ... | 6 | 650 | 1894 | 64 when drilled, ceased flowing this summer. | 30 with big leak... | 62 | Up Frankforter Creek. Diameter below 44 feet is 4½ inches. |
| Lytle ranch well..... | Sec. 17, T. 33, R. 2 W ... | 2,3 | 400 | 1887 | 25½ with big leak.. | 3..... | 62½ | Passed through 10 feet of bowlders at depth of 50 feet. Formerly had high pressure. |
| Mastin Mische..... | E. ½ sec. 20, T. 33, R. 2 W. | 2 | 600 | ..... | Weak now, was very strong. | 6..... | 62 | About 70 feet above the Missouri River. |
| Kate Phelps well.... | SE. ¼ sec. 16, T. 33, R. 2 W. | 1 | 400 | ..... | 11..... | 3..... | 62 | On Missouri bottom. |
| John Mische..... | .....do..... | 2 | 395 | ..... | Weak..... | 9..... | 60 | On Missouri bottom, near chalk bluff. |
| Chas. Mische, lot well. | Sec. 15, T. 33, R. 2 W ... | 2 | 405 | ..... | 14 now, with leak. | ..... | 59½ | Part way up chalk bluff. |
| A. P. Sage..... | Sec. 13, T. 33, R. 2 W ... | 2 | 700 | ..... | Does not flow.... | ..... | ..... | Used as a tubular well: 200 feet above river. |
| Chas. Mische..... | Sec. 15, T. 33, R. 2 W ... | 2 | 425 | ..... | 14 now, with leak. | 9..... | 61 | Part way up chalk bluff. |

### CEDAR COUNTY.

The most extensive surface deposit in Cedar County is the loess, below which lie Quaternary and Tertiary sands, clay, and gravel. Of the Cretaceous formations only a few detached areas of Pierre clay occur, while Niobrara chalk rock underlies all of the county, either beneath later formations or at the surface. The other members of the Cretaceous exposed along the Missouri lie at lower levels beneath the chalk.

The surface of the county is for the most part gently rolling, with drainage to the northeast and southeast. The principal streams, aside from the Missouri, are Bow and West Bow creeks, which converge north of St. James. The southern and southeastern townships are drained by Logan Creek.

*Springs.*—The big springs near Coleridge were well known in the early history of the county as a watering place for immigrants. Curlew Springs, issuing from banks beneath the drift in a boggy slough, are also well known. The Frank Hochstein Spring on sec. 8, T. 32, R. 2, is perhaps the finest in the county. It is located at the foot of a loess-capped hill and the water boils up from a circular hole the depth of which has not been ascertained. The flow is between 400 and 500 gallons per minute, which, according to the owner, has not changed in thirty-eight years. The water deposits some iron and on that account is usually regarded as coming from the artesian supply. The temperature is only 50½°. The water is used for drinking, domestic and dairy purposes, and stock.

*Shallow wells.*—In this county there is usually an abundance of good water available in shallow wells, from Tertiary and Glacial sands and gravels. In some localities the wells extend into the chalk rock, which gives very hard water but contains less alkali than farther west, the formation appearing to be leached out in this county. Not many shallow wells are found along the Missouri bottom, the water supply there being derived from artesian wells.

The depth of common or shallow wells is controlled to a considerable degree by the topography. In the broad valleys water is obtained at a depth of a few feet, usually from 10 to 40, while on some of the intervening ridges and high lands the depth to it is considerably greater.

About Hartington the depths vary from about 15 to 35 feet and at Coleridge from 20 to 45 feet.

*Representative shallow wells of Cedar County, Nebr.*

| Owner. | Location. | Depth. | Diameter. | Depth of water. | Quality. | Remarks. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Inches.* | *Feet.* | | |
| Chas. Clark | Sec. 21, T. 33 N., R. 1 W. | 60 | 24 | 15 | Hard | Soil, clay 20–30 feet; chalk rock. |
| James Marsh | Sec. 16, T. 33, R. 1 W. | 72 | 24 | 20 | do | Good drinking; soil, clay; chalk rock. |
| Town well | Sec. 16, T. 33, R. 1 W. | 70 | 60 | 11 | Medium | Soil to 12 feet; sand; soil; gravel with water. |
| H. Wubben | NE¼ sec. 23, T. 33, R. 1 E. | 100 | 36 | ..... | Hard | Soil; loess 30 feet; red chalk rock 20 feet; blue chalk 48 feet. |
| Carl Doeller | Sec. 35, T. 33, R. 1 E. | 50 | 48 | 2 | do | Soil; loess 44 feet; chalk. |
| L. P. Lauretzen | Sec. 26, T. 32, R. 2 E. | 50 | 48 | 10 | do | |
| Ernest Ferber | Sec. 1, T. 31, R. 2 E. | 36 | 2 | ..... | ..... | Black dirt 3 feet; sand 22 feet; balance gravel. |
| W. H. Hight | Sec. 9, T. 29, R. 2 E. | 13 | 39 | 9 | Medium. | Soil, gumbo; sand in bottom. |
| Ed Fiscus | Sec. 18, T. 29, R. 3 E. | 55 | 2½ | .... | Hard | Soil, silty; loess 51 feet; sand with water at bottom. |
| R. C. Chase | Sec. 34, T. 30, R. 3 E. | ..... | 30 | ..... | do | Loess, sand, and gravel; is 60 feet below highest hills. |

*Artesian wells.*—There are nearly 100 flowing artesian wells in Cedar County, all of which are either along or near the Missouri bottom. Their distribution is shown on Pl. IX (in pocket), and most of their features are given in the table, page 47. In addition to these there are many tubular wells on the highlands to the south, some of which flowed for a short time. The supply in these tubular wells comes from the artesian water in the Dakota sandstone and rises as high in these wells as it would in pipes at artesian wells on the Missouri bottom. Mr. Chamberlain, who drilled most of the wells in Cedar County, states that flowing wells can be had up West Bow Creek for 7 miles and up Bow Creek for 6 miles from the river. Beyond that distance they cease to flow.

This important resource should be protected by more careful casing of wells; all should be cased to the cap rock and kept under control at the surface. As it is there is an enormous loss by underground leakage and the waste of flows on the surface.

*Record of artesian well at St. Helena, Nebr.*

| | Feet. |
|---|---|
| Chalky limestone | 0– 25 |
| Shale | 25– 59 |
| Dark blue clay | 59–329 |
| Shale | 329–369 |
| Black shale with hard layers and lignite 6 inches thick at 399 and 418 feet | 369–418 |
| Sand with flow, underlain by clay | 418–466 |

*Artesian wells of Cedar County, Nebr.*

| Owner. | Location. | Depth. | Diameter. | When drilled. | Pressure. | Yield per minute. | Temperature. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| | | *Feet.* | *Inches.* | | *Pounds.* | *Gallons.* | *° F.* | |
| Frans Nelson | NW. ¼ sec. 17, T. 33, R. 1 W. | 500 | 1¼ | | Weak | | 59 | Soil; chalk to perhaps a little below the river clay, hard beds, and shale to sand rock. |
| Albert Miller | Sec. 18, T. 33, R. 1 W | 648 | 3½ | | None | | | Water raised to within 56 feet of the surface about 200 feet above river. |
| D. Miller | NE. ¼ sec. 17, T. 33, R. 1 W. | 365 | 2 | 1898 | 15 | 26 at first | 59½ | Soil; sand 45 feet; no chalk; clay and shale for most of distance; thin cap rock with porous sand rock beneath. Flow at 337 feet. |
| John Nelson | SW. ¼ sec. 16, T. 33, R. 1 W. | 400 | 2 | 1883 | Weak | | 59½ | About 10 feet above river. |
| Do | SW. ¼ sec. 16, T. 33, R. 1 W. | 400 | 2 | | 14 | 7 now | 60 | On Missouri bottom. |
| John Aten | Sec. 16, T. 33, R. 1 W | 400 | 2 | 1896 | 9 now | 7 | 58½ | Do. |
| Eugene Saunders | SE. ¼ sec. 9, T. 33, R. 1 W. | 400 | 2 | 1896 | 8 | 7 | 58½ | On Missouri bottom. Diameter reduced to 1 inch at top. |
| Joseph Holtzbauer | SE. ¼ sec. 10, T. 33, R. 1 W. | 400 | 2 | 1895 | Strong | 15 | 59 | Soil and sand, 181 feet; clays, shale, and hard rock to water rock. |
| J. H. Coacher | SW. ¼ sec. 11, T. 33, R. 1 W. | 380 | 2 | | | | | Rusted pipe. Used as tubular well. |
| John Nelson | Sec. 12, T. 33 R. 1 W | 400 | 2 | | About 13 | 7 | 59½ | Pressure was stronger. |
| L. Hoesing (Eikhoff well) | Sec. 30, T. 33, R. 1 W | | | | None | Does not flow | | On high ground. Tubular. |
| William Lackman | NE. ¼ sec. 27, T. 33 R. 1 W. | | 2 | | do | do | | Flowed for a time. Used as tubular well now. |
| Dave Nelson | Sec. 12, T. 33, R. 1 W | 380 | 2 | 1897 | Strong | 44 | 60 | |
| Albert Lee | Sec. 8, T. 33, R. 1 E | 360 | 2 | 1896 | Weak | 78 when drilled; 52 now. | 59½ | Soil, 4 feet; quicksand, 20 feet; coarse sand and gravel, 30 feet. The rest of the way blue clay, with few layers of hard rock ranging from 3 inches to 3 feet in thickness. |
| C. B. Clark | NW. ¼ sec. 17, T. 33, R. 1 E. | 420 | 2 | | Good | | 69 | |
| H. Yager | Sec. 16, T. 33, R. 1 E | 360 | 2 | 1889 | Weak | 5½ | 58 | On Missouri bottom. |
| M. U. Hoyt | SW. ¼ sec. 17, T. 33, R. 1 E. | 454 | 1½ | 1893 | Fairly strong | | 58½ | Is used for the house, barn, and three pastures. |
| Dave Nelson | NE. ¼ sec. 15, T. 33, R. 1 E. | | 1½ | 1892 | Weak | 40 | | On Missouri bottom. |
| Mrs. Mary Bruns | Sec. 23, T. 33, R. 1 E | 500 | 1½ | | do | | | |
| Joe Baehmer | Sec. 22, T. 33, R. 1 E | 500 | 2 | 1890 | Ceased to flow | | | First flow at 290 feet; second flow at 500 feet. |
| Do | Sec. 22, T. 33, R. 1 E | 500 | 2 | 1896 | Strong | 15 to 20 | 62 | |
| George Housman | Sec. 24, T. 33, R. 1 E | 350 | 2 | | Strong; was 35 | Full pipe | 60 | |
| A. Tielke | Sec. 25, T. 33, R. 1 E | 630 | | | Does not flow | Does not flow | | Temperature warm. |
| H. Brunig | Sec. 25, T. 33, R. 1 E | 602 | 2 | 1894 | | At first 25; does not flow now. | | Clay, 200 feet; limestone, 25 feet; clay, 60 feet; hard rock, 40 feet. |
| John Cooper | Sec 25, T. 33, R. 1 E | 520 | 2 | | Was strong | Does not flow now | | Temperature was warmer than shallow well. |
| Kate Housman | Sec. 30, T. 33, R. 1 E | 530 | 2 | 1901 | 19 | 30 at first | 63 | |
| John Statman | Sec. 30, T. 33, R. 1 E | 600 | 2 | | | | | Flowed for short time only. Now used as tubular well. |
| M. C. Smidt | Sec. 32, T. 33, R. 1 E | | 2 | | None | Ceased to flow | | Soil, etc., 20 to 30 feet; chalk; clay over 100 feet; hard rock; clay and shale, 100 feet; sand and sandstone. Ran out of pipe at 300 feet. Water lifted at 120 feet, but did not flow out. |

*Artesian wells of Cedar County, Nebr.*—Continued.

| Owner. | Location. | Depth. | Diameter. | When drilled. | Pressure. | Yield per minute. | Temperature. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| | | *Feet.* | *Inches.* | | *Pounds.* | *Gallons.* | °*F.* | |
| T. N. Jones | Sec. 34, T. 33 N., R. 2 E. | 280 | 2 | 1893 | Fairly strong | Pipe nearly full in horizontal position. | 60 | On Missouri bottom lands. |
| W. C. Jones | Sec. 28, T. 33, R. 2 E. | 420 | 2 | 1893 | Strong | | 60½ | |
| Do | Sec. 29, T. 33, R. 2 E. | 200 | 2 | 1896 | do | Pipe nearly full | 60½ | |
| Do | Sec. 28, T. 33, R. 2 E. | 300 | 2 | | | Ceased flowing | | |
| Frank Arens | Sec. 34, T. 32, R. 1 E. | 535 | 3 | 1889 | | 2 | | |
| B. Wubben | SW. ¼ sec. 5, T. 32, R. 2 E. | 500 | 2 | | Weak | 4 | 61 | |
| Do | SW. ¼ sec. 5, T. 32, R. 2 E. | 600 | 2, reduced to 1¼ below. | | At first 4 | Weak at first, ceased flowing. | | Passed through considerable chalk. |
| C. E. Klapping | Sec. 10, T. 32, R. 2 E. | | 2 | | Weak | | 60½ | |
| Frank Wiesler | Sec. 9, T. 32, R. 2 E. | | 2 | | do | 5 | 60 | |
| Peter Hochstein | SW. ¼ sec. 8, T. 32, R. 2 E. | 530 | 2 | 1888 | do | 2 | 60½ | |
| Ernest Ferber | NE. ¼ sec. 10, T. 32, R. 2 E. | 241 | 2 | 1886 | do | Two 1¼-inch pipes full. | 60 | |
| T. N. Jones | NE. ¼ sec. 10, T. 32, R. 2 E. | 2 | 400 | 1890 | Was 30, now 17 with leak. | Pipe full | 60 | First flow forced water 56 feet above the bottom, second flow strong, third stronger. |
| Jacob Keizer | SE. ¼ sec. 9, T. 32, R. 2 E. | 2 | 500 | 1893 | None now | Flows a little out of ditch 6 feet deep. | | |
| August Hochstein | SW. ¼ sec. 10, T. 32, R. 2 E. | 2 | 360 | 1894 | Strong | Horizontal pipe nearly full. | 59 | In Bow Creek Valley. |
| F. Ashbre | NE. ¼ sec. 12, T. 32, R. 2 E. | 2 | 300 | | do | 11 | 59 | |
| James Keegan | SE. ¼ sec. 14, T. 32, R. 2 E. | 2 | 400 | | Weak | 1 | 60 | |
| John Hochstein | NW. ¼ sec. 15, T. 32, R. 2 E. | 2 | 320 | | do | Size of finger flow | 59 | Do. |
| W. D. Schulte | NE. ¼ sec. 23, T. 32, R. 2 E. | 2 | 360 | 1887 | 30 | 60 | | |
| A. W. Jones | NE. ¼ sec. 11, T. 32, R. 2 E. | 2 | 417 | 1896 | 10 | Flows horizontal pipe (2 inches) half full. | 58 | |
| Do | Sec. 11, T. 32, R. 2 E. | 2 | 300 | 1893 | Could not gage | Flows 2-inch horizontal pipe. | 58½ | |
| Ferd Ashbre | NW. ¼ sec. 13, T. 32, R. 2 E. | 2 | 400 | | Weak | | 59 | |
| St. James Well | NW. ¼ sec. 24, T. 32, R. 2 E. | 2 | 540 | | None | Does not flow now. | | |
| Bert Thompson | NW. ¼ sec. 24, T. 32, R. 2 E. | 2 | 300 | | Weak | 2½ | 59 | |
| F. Leise | SE. ¼ sec. 25, T. 32, R. 2 E. | 2 | 340 | | do | 2 | 58 | |
| Do | Sec. 25, T. 32, R. 2 E. | 2 | 400 | | Was weak | Flow ceased | | |
| Peter Kugan, Ashmole Well. | NE. ¼ sec. 14, T. 32, R. 2 E. | 2 | 520 | 1894 | Strong | Flows horizontal pipe full. | 62½ | |
| Nels Anderson | Sec. 23, T. 32, R. 2 E. | 2 | 400 | 1888 | Weak | 30 | | 270 feet to water. |
| H. E. McKenzie | Sec. 24, T. 32, R. 2 E. | 2 | 448 | 1894 | | | | At first flowed pipe full. |
| Jones-McKenzie | SE. ¼ sec. 7, T. 32, R. 3 E. | 2 | 40 | | 16 | Flows a 2-inch pipe nearly full. | 61 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Richard Brewer | SW. ¼ sec. 8, T. 32, R. 3 E. | 2 | 400 | 1900 | Nearly 4 now | Runs 2-inch horizontal pipe nearly full. | 60½ | Pressure varies with season. Strong when drilled. Decreased six months after. |
| Do | NE. ¼ sec. 8, T. 32, R. 3 E. | 2 | 300 | 1893 | Weak | 1½ | 58½ | |
| H. Wiseman | SE. ¼ sec. 8, T. 32, R. 3 E. | (a) | 280 | 1883 | Could not determine. | | 58½ | |
| T. W. Whitehouse | Sec. 9, T. 32, R. 3 E. | 2 | | | | | | 15 feet above river. |
| Riley Brewer | Sec. 9, T. 32, R. 3 E. | 2 | 280 | | | Runs ⅓ pipe full | 59 | |
| Mrs. L. Larson | SW. ¼ sec. 11, T. 32, R. 3 E. | 2 | 280 | | None; was fairly strong. | None | | Flow stopped in 1902, owing to rusted pipe. |
| S. Boyles | NE. ¼ sec. 15, T. 32, R. 3 E. | 2 | 365 | | 6 | 7 | 57 | Well not well cared for. Overflows, forming a marshy pond. |
| Theodore Beste | SW. ¼ sec. 15, T. 32, R. 3 E. | 2 | 310 | 1900 | 17 | Good flow | 60 | |
| Do | NE. ¼ sec. 15, T. 32, R. 3 E. | 2 | 240 | | Weak | 3 | 58 | |
| Do | NE. ¼ sec. 16, T. 32, R. 3 E. | 2 | 270 | | do | 4 | 58½ | |
| Do | SW. ¼ sec. 12, T. 32, R. 3 E. | 2 | 310 | 1891 | Weak now; 18 when drilled. | 8 | 59½ | |
| C. B. Larson | NW. ¼ sec. 15, T. 82, R. 3 E. | 2 | —300 | | 1 | 1¼ now | 56 | Overflows into pond or marshy place near house. |
| Nels Anderson | SW. ¼ sec. 21, T. 32, R. 3 E. | 2 | | | Just fair | 3 or 4 | 59½ | |
| Do | NW. ¼ sec. 21, T. 32, R. 3 E. | 2 | 340 | | Very weak | 1 | 59 | |
| Do | NE. ¼ sec. 22, T. 32, R. 3 E. | 2 | 400 | | None | No flow now | | |
| Do | Sec. 23, T. 32, R. 3 E. | 2 | 400 | 1888 | | 1 barrel | | |
| Ferd Ashbre | Sec. 16, T. 32, R. 3 E. | 2 | 40 | | Fair | 5 | 59½ | |
| Do | Sec. 7, T. 32, R. 3 E. | 2 | 300 | | Not strong | | 59 | 35 feet above river. |
| J. W. Gowery | Sec. 21, T. 32, R. 3 E. | 2 | 327 | 1893 | 2 | | 55½ | |
| Do | Sec. 21, T. 32, R. 3 E. | 2 | 310 | | Weak | 3 | 55 | Just flows. |
| Herman Koch | NE. ¼ sec. 14, T. 32, R. 3 E. | 2 | 270 | 1893 | Could not gage | 20 | 59¼ | |
| Fred Riefenrath | SE. ¼ sec. 12, T. 32, R. 3 E. | 2 | 250 | | Was 12 | 8 | 57 | Drilled about 12 years ago. |
| Do | NE. ¼ sec. 23, T. 32, R. 3 E. | 2 | 530 | 1886 | Weak now | 12 | 59 | When first drilled this well was the cause of considerable trouble between its owner and parties owning land over which the water flowed. |
| Frank Reifenrath | SW. ¼ sec. 11, T. 32, R 3 E. | 2 | 245 | 1887 | Could not gage | 11 | 57½ | Owner could not give log. Casing at first 1¼ inches; then 2 inches, and became strong again. Owner is 83 years old. |
| Chris Sartorius | SE. ¼ sec. 13, T. 32, R. 3 E. | 2 | 255 | 1887 | | 7 | | When first drilled volume 40 gallons per minute. |
| Swan Anderson | Sec. 24, T. 32, R. 3 E. | 2 | 280 | | Weak | Enough to form quite a lake northwest of house. | 69 | Is piped to different lots about the barn. Runs in a large tile, 3 feet high, near the house. The pressure is little more than enough to lift the water to this level, as there is only a weak overflow. Temperature given was in the large tile. |
| J. C. Dawson | NE. ¼ sec. 24, T. 32, R. 3 E. | 2 | | | | Horizontal pipe, 1 inch at top, full. | 63½ | |
| Do | Sec. 24, T. 32, R. 3 E. | 2 | 340 | 1890 | Weak, pipe leaks | 2 | 60 | Much $H_2S$ in water. |
| John Lammers | Sec. 35, T. 32, R. 3 E. | 2 | 600 | 1885 | Ceased flowing | All that 2-inch casing could hold. | | |

a 1½ inches, 1¼ now.

### DIXON COUNTY.

The southwestern part of Dixon County resembles adjacent parts of Cedar County in topography, structure, and water conditions. In most other portions, except on the bottom land and along the bluffs on the Missouri, loess-covered hills predominate. The amount of sand and gravel beneath the loess appears to decrease to the northeast. The northwestern part of the county is underlain by Niobrara chalk rock. Glacial clay appears to be more widely distributed than in Cedar County.

Very little difficulty is experienced in obtaining a good supply of water, the Benton clays being the only beds that yield well water unfit for use. The principal water-power stream, the Aowa, is not strong, but inexpensive dams at Ponca and Martinsburg, constructed of brush, stone, and soil, afford water power for flouring and grist mills.

*Springs.*—Many springs occur in the county, one of the most notable of which is at Waterbury, where the flow has been used for locomotives. The water here rises from a considerable depth into a large circular basin near the station. One-half mile south a similar spring 45 feet across and 20 feet deep, flows between 300 and 400 gallons of water a minute, never freezing over during winter.

The Hurley Springs, about 5 miles west of Martinsburg, come out of sands above bowlder clay at an altitude of 1,425 feet. South of this place there is a general seepage from the slope at an altitude of 1,500 feet.

*Shallow wells.*—Much of the domestic water supply is from very shallow wells, which are affected somewhat by dry weather. In several localities the water table comes so near the surface that flowing wells might be had. One well 45 feet deep, at the stock yards in Allen, overflows. At Allen the water rises to within 12 feet of the surface, from a bed of gravel which lies at a depth of 70 feet. The following representative wells show the prevailing conditions in this county:

*Representative shallow wells of Dixon County, Nebr.*

| Owner. | Location. | Depth. | Diameter. | Depth of water. | Quality. | Remarks. |
|---|---|---|---|---|---|---|
| | | *Feet.* | *Inches.* | *Feet.* | | |
| Town well of Wakefield | Sec. 32, T. 27 N., R. 5 E. | 80 | 6 | 60 | Very good, hard | Black loam 10 feet; clay 30 feet; gravel. |
| J. W. Hypse | Sec. 24, T. 27, R. 4 E. | 104 | 2 | 80 | Hard | Black loam 4 feet; clay, sand, and gravel 100 feet. |
| Peter Norell | Sec. 25, T. 27, R. 4 E. | 67 | 36 | 25 | Bad, hard | Loam 2 or 3 feet; red clay, gravel, blue clay. |
| G. A. Herrick | Sec. 33, T. 29, R. 6 E. | 27 | 3½ | 7 | | |
| R. C. Caulk | Sec. 9, T. 28, R. 5 E. | 266 | 5 | 56 | Hard | Yellow clay 111 feet; 31 feet to dry sand; dry gravel 18 feet; sand rock 1½ feet; dry sand 30 feet; 30 feet water; clay and sand 2 feet; water gravel 26 feet; light yellow clay 8 inches. |
| Benson Grain Co | Sec. 26, T. 28, R. 6 E. | 55 | 1½ | | do | |
| Ioderson | NW. ¼ sec. 11, T. 29, R. 4 E. | 155 | | | | Soil and loess 10; sand 6; yellow clay 34; blue clay (granules) 100; sand and water 5 feet. |
| Maggie Hurley | NE. ¼ sec. 10, T. 29, R. 5 E. | 71 | 5 | 30 | Hard | Soil, sand, and gravel mixed with clay, 15 feet; soil; blue clay to water. |
| D. Hurley | NE. ¼ sec. 2, T. 29, R. 5 E. | 45 | 6 | 18 | do | Reached second water. |
| Lawrence Phillips | Sec. 7, T. 29, R. 5 E. | 15 | 36 | 10 | do | |
| Dennis Hurley | Sec. 10, T. 29, R. 5 E. | 26 | 3½ | 22 | do | Water in blue clay—affected very little in dry seasons. |
| Do | do | 44 | 6 | 26 | | Can not be pumped dry. |
| J. E. Ekersoth | Sec. 22, T. 30, R. 6 E. | 22 | 36 | 18 | Hard | |
| Gilbert Bros | Sec. 28, T. 30, R. 3 E. | 60 | 36 | 14 | do | Soil, loess 40 feet; blue glacial clay 22 feet; sand and gravel. |
| A. Wiedenfeld | Sec. 6, T. 30, R. 4 E. | 80 | 24 | 15 | | Loess 50 feet; cobblestone and gravel 5 feet; blue clay 25 feet. |
| Sam. Thomas | NW. ¼ sec. 24, T. 30, R. 4 E. | 156 | | 36 | | Loess 100 feet; sand 56 feet. |
| Nick Thomas | SW. ¼ sec. 12, T. 30, R. 4 E. | 265 | | 65 | | Loess 40, blue clay and sand 60, sand 150, and shaly clay 15 feet. |
| John Rahn | NW. ¼ sec. 34, T. 30, R. 5 E. | 301 | | Many. | | Loess 60, blue clay (Benton) 210, sandstone with water (Dakota) 29 feet. |
| O. J. Anderson | NE. ¼ sec. 33, T. 32, R. 4 E. | 167 | | 10 | Good | Loess 130, dry sand 11, sandy clay 8, and fine sand with water 18 feet. |

*Artesian wells.*—There are a few artesian wells on the bottom lands in the northern part of the county. If wells were sunk to the lower beds of the Dakota formation and carefully cased, flows could be had several miles farther southeast. There are also a number of deep tubular wells located on high land south of the Missouri bottom. The following wells are now flowing:

*Artesian wells of Dixon County, Nebr.*

| Name. | Location. | Depth. | Diameter. | Length of casing. | When drilled. | Pressure. | Yield per minute. | Temperature. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | *Feet.* | *Inches.* | *Feet.* | | *Pounds.* | *Gallons.* | *F.°* | |
| Chris Sartorious | Sec. 19, T. 32 N., R. 4 E. | 300 | 2 | 70 | | Weak | 2 | 61 | Pipe leaks. |
| Fred Reifenrath | Sec. 19, T. 32, R. 4 E. | 300 | 1½ | 65 | | do | 2 | 61 | Pipe rusted. |
| J. P. Warnick | Sec. 29, T. 32, R. 4 E. | 280 | 2 | 60 | 1893 | 2 now | 1 | 61 | Pressure 8 pounds when drilled. |
| Do | NE. ¼ sec. 29, T. 32, R. 4 E. | 280 | 2 | 70 | 1898 | Weak (leaks) | | 60½ | Flows pipe half full. |
| C. Weeks | Sec. 28, T. 32, R. 4 E. | 290 | 2 | At first 50; now 1-inch pipe to bottom. | | 5½ | | 60¼ | Flowed at 240 feet. Pressure 9 pounds when drilled. |
| Thomas Warnick | NW. ¼ sec. 28, T. 32, R. 4 E. | 277 | 2 | 60 | 1899 | 6 now; was 8 | | 60¾ | Sand, 70 feet; limestone and clay, 80 feet; sandstone and water, 27 feet. |
| Do | Sec. 28, T. 32, R. 4 E. | 177 | 2 | 60 | 1901 | Weak | | 59 | Shallowest well in this region. |
| Butler Bros | Sec. 34, T. 32, R. 4 E. | 300 | 2 | | | None | 1 | 58 | Pipe rusted off. |
| Dexter Rice | Sec. 28, T. 32, R. 5 E. | 265 | 2 | 40 | 1888 | Nearly 10 | | 61 | Pressure 10 pounds when drilled. First flow at 160 feet. |
| T. J. Ryan | Sec. 32, T. 32, R. 5 E. | 265 | 2 | At top 3 inches in diameter. | 1896 | 2 now | 3 | 55 | Pressure 8 pounds when drilled. |
| Do | Sec. 32, T. 32, R. 5 E. | 400 | 2 | | 1886 | 12½ originally | 3 | 54 | Flowed 50 gallons when drilled. |
| Geo. Mathison | Sec. 20, T. 31, R. 6 E. | 484 | 3 | | 1888 | None | | | Flowed 3 weeks. Rises within 3 feet of top. |

### DAKOTA COUNTY.

Dakota County resembles Dixon in configuration but includes a much wider area of bottom lands along the Missouri. Its uplands are deeply trenched by the small valleys of many watercourses, with the intervening ridges or plateau remnants thickly capped by loess. Cretaceous rocks from Dakota to Greenhorn appear in the slopes and often present extensive outcrops. The Missouri bottom land is thickly floored by alluvial deposits.

The principal stream is Missouri River, which defines the eastern boundary. There are several creeks of moderate size, the most notable of which is Elk Creek, a stream which flows with a remarkably crooked course north from Emerson to Goodwin, then east and southeast to Jackson, and finally southeast and east to the river northeast of Homer. There is much surface water, but the principal water supplies are from the numerous springs and shallow wells.

*Springs.*—Many springs issue from the Dakota sandstone, which outcrops from above Jackson to the southeastern part of the county. These afford an abundance of good cool water for drinking, domestic purposes, and stock. A spring in sec. 24, T. 28 N., R. 8 E., 2 miles northwest of Homer, has been used for forty-eight years for domestic supply and as a public watering place. It flows 6 gallons a minute, with a temperature of 51°.

The Miller Spring, a short distance northwest of Homer, is piped from a tile sunk in the sand; part of the flow fills a 1-inch pipe.

At a ranch a half mile north of Homer the sand rock has been dug into and a reservoir walled up, from which runs enough water to fill a 2-inch pipe. A half mile north of this place there is one of the strongest springs in the vicinity, and about 6 miles southwest of Jackson there are two very strong springs.

*Wells.*—Underground-water conditions are much the same as in Dixon County, except that the Dakota sandstone rises nearer to the surface and is easily reached by tubular wells. There are no artesian wells in the county; the artesian water reached in such wells farther west issues here as springs.

The following is the record of a tubular well on high ground 6 miles southwest of Jackson: Loess, 90 feet; sand and hard spongy clay, 6 feet; dark clay with a bed of limestone near the middle, 156 feet; sand rock with good water, 6 feet.

Wells on or near the bluffs between Jackson and Homer are usually 80 to 100 feet deep, but several in Jackson are deeper. The Ashford well at Homer is 184 feet deep. The supply is usually good, but in the Ashford well the water is poor on account of improper casing through clay beds which carry soluble salts. On the bottom lands the depth to the first water varies from 20 to 25 feet, but at 35 feet

the water is usually poor. Formerly most wells were drilled to the greater depth, but now they are driven to the first water. According to reports by well drillers the alluvium southeast of Jackson is from 80 to 100 feet deep. A steady supply of good drinking water is obtained at Homer in a well 40 feet deep. In the southwestern part of the county wells are very shallow, but yield inexhaustible supplies.

## AGRICULTURAL RESOURCES.

### SOILS.

The soils of the region are of several types, having been formed by various agencies acting on rocks of different kinds; most of them are closely related to the underlying formations. Much of the eastern and central parts of the area lies in the fertile loess region, where the soil is deep and easily worked, receives and holds moisture well, and yields heavy crops on both hilly and level lands. The alluvial bottom-land or flood-plain soil is also fertile and easily tilled, but in the lowest areas fields are often damaged by high waters and by shifting of the river channel. The heavy Pierre clay, or gumbo soil, is especially extensive in Boyd County; it contains some alkali and often affords bad water, but usually produces good grass and heavy yields of corn, oats, and wheat, especially where the clay is mixed with sand. The sandy upland soils in Cedar, Knox, Holt, and western Boyd counties stand droughts well and are gradually being utilized.

### CROPS.

The principal crops are hay, corn, wheat, and oats, but alfalfa and sugar beets are also successfully grown. Mixed farming is practiced generally, except at points where the land is too sandy, or the topography is not favorable. Every county has a large acreage of hay land; in Cedar County this crop is grown principally along broad creek basins. While corn grows well throughout most of the region, it does best at certain points on the Missouri bottom. The heaviest yield of oats per acre in 1903 was in Boyd County, southeast of Spencer, and near Gross. Grain elevators are found at every railroad station. The reported acreage of the principal grain crops in 1902, not including Holt County, was as follows: Corn, 279,055; wheat, 105,981; oats, 115,958; rye, 12,680; barley, 4,877.

### STOCK RAISING AND DAIRYING.

One of the most important industries in the region is cattle raising, and in many localities wide areas are used for grazing, especially where the land is too rough or too sandy for farming. The principal pasture lands are in the northern part of the Santee Indian Reservation in Knox County, in southwestern Knox County, in the

sandy and rough portions of Holt and western Boyd counties, and on the bluff and ravine lands along Missouri River. Hogs, sheep, and horses are also raised in large numbers.

Dairying has attained an important place in the economy of the region. Cream is shipped from nearly all the railroad stations, Holt County leading in its production in the State of Nebraska.

## TIMBER.

The timber growth is of considerable importance in most of the counties. It occurs mostly along the river and creek bottoms and up many ravines. The principal trees of economic importance are cottonwood, bur oak, elm, and scattering walnut; some of these are as much as 4, 5, or even 6 feet in diameter. The timber is used for posts, firewood, lumber, frames, and bridges. Sawmills operate at a number of points, as north of St. Helena, northwest of St. James, on Brooky bottom, and west of Aten. The sawmills obtain their timber principally from caving banks along the rivers, where the timber would be rapidly destroyed if not removed. The bur-oak growth is thickest in northern Dixon and Cedar counties, where it is cut into posts for which there is much demand. Timber cutting begins about September and lasts during the autumn and winter.

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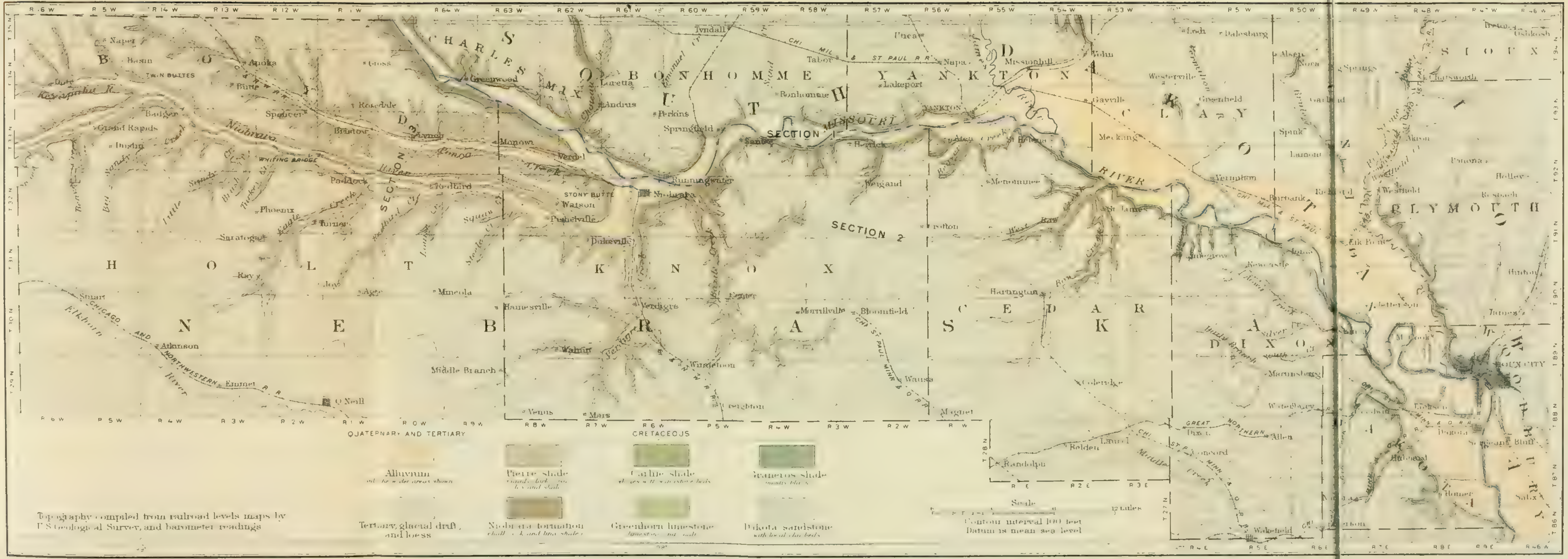
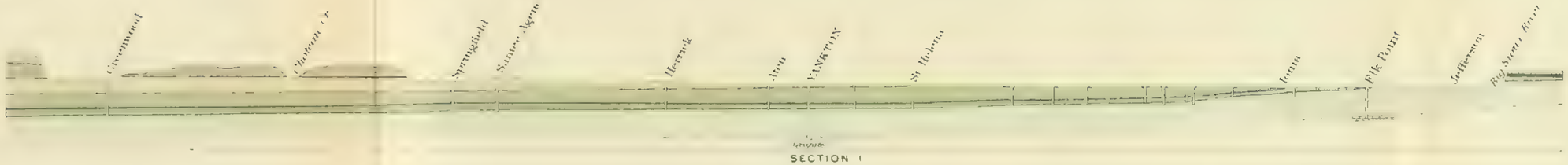



PRELIMINARY GEOLOGIC MAP OF NORTHEASTERN NEBRASKA, BY G E CONDRA, WITH ADJACENT PORTIONS OF SOUTH DAKOTA AND IOWA, BY J E TODD
PREPARED UNDER DIRECTION OF N H DARTON

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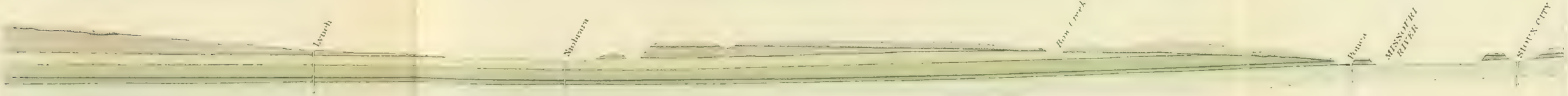


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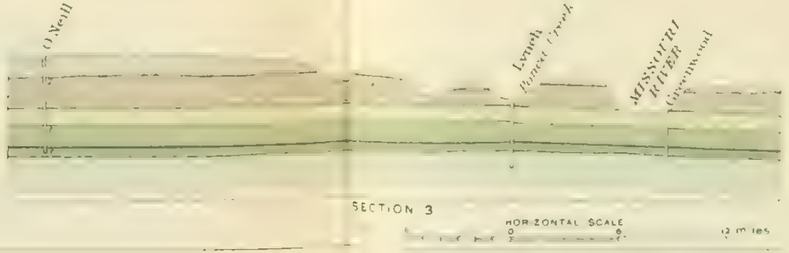


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Glacial drift, loess, and tertiary

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Carlile shale

Graneros shale

Granite limestone etc.

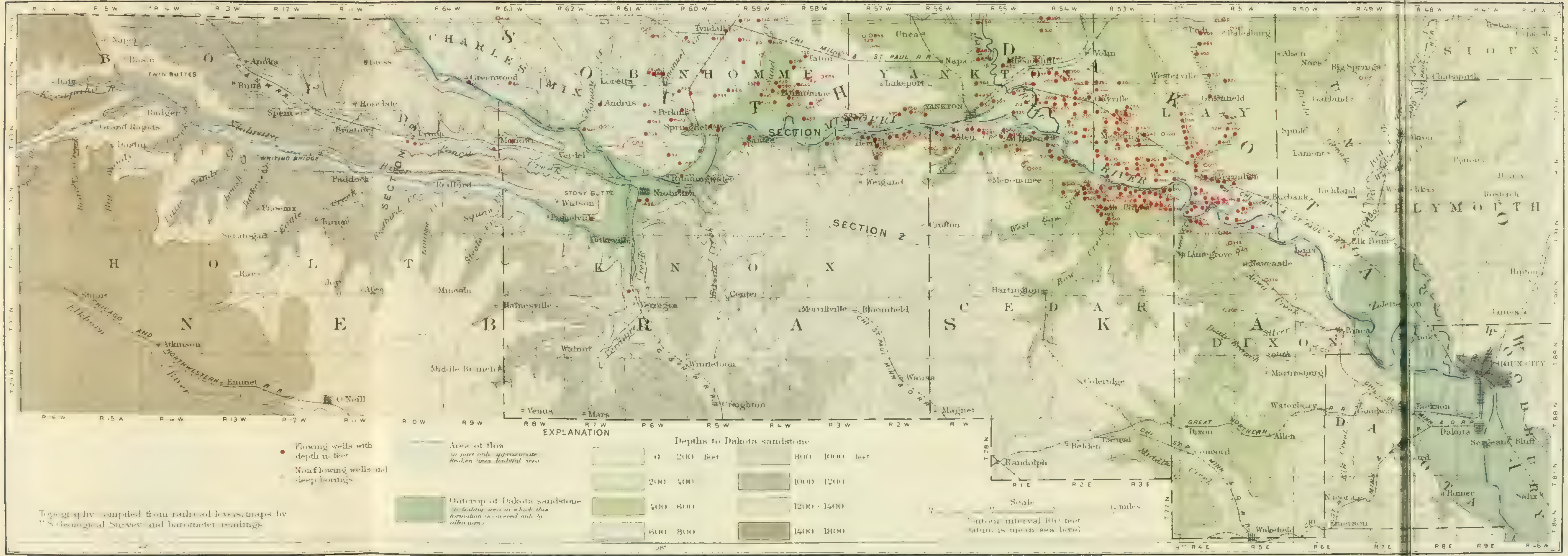
Niobrara formation

Greenhorn limestone

Dakota sandstone

VERTICAL SCALE
3000 feet

SECTIONS ACROSS NORTHEASTERN NEBRASKA AND ADJACENT PORTIONS OF SOUTH DAKOTA AND IOWA
BY N. H. DARTON, G. E. CONDRA, AND J. E. TODD




MAP OF NORTHEASTERN NEBRASKA AND ADJACENT PORTIONS OF SOUTH DAKOTA AND IOWA, SHOWING UNDERGROUND WATER CONDITIONS
BY N. H. DARTON, MAINLY FROM DATA BY G. E. CONDRA AND J. E. TODD, 1905

Water-Supply and Irrigation Paper No. 216

Series { A, Economic Geology, 97
B, Descriptive Geology, 119
M, General Hydrographic Investigations, 26
O, Underground Waters, 72

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

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# GEOLOGY AND WATER RESOURCES

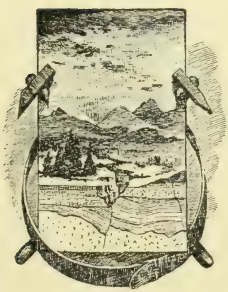
## OF THE

# REPUBLICAN RIVER VALLEY

## AND ADJACENT AREAS, NEBRASKA

BY

G. E. CONDRA



WASHINGTON

GOVERNMENT PRINTING OFFICE

1907

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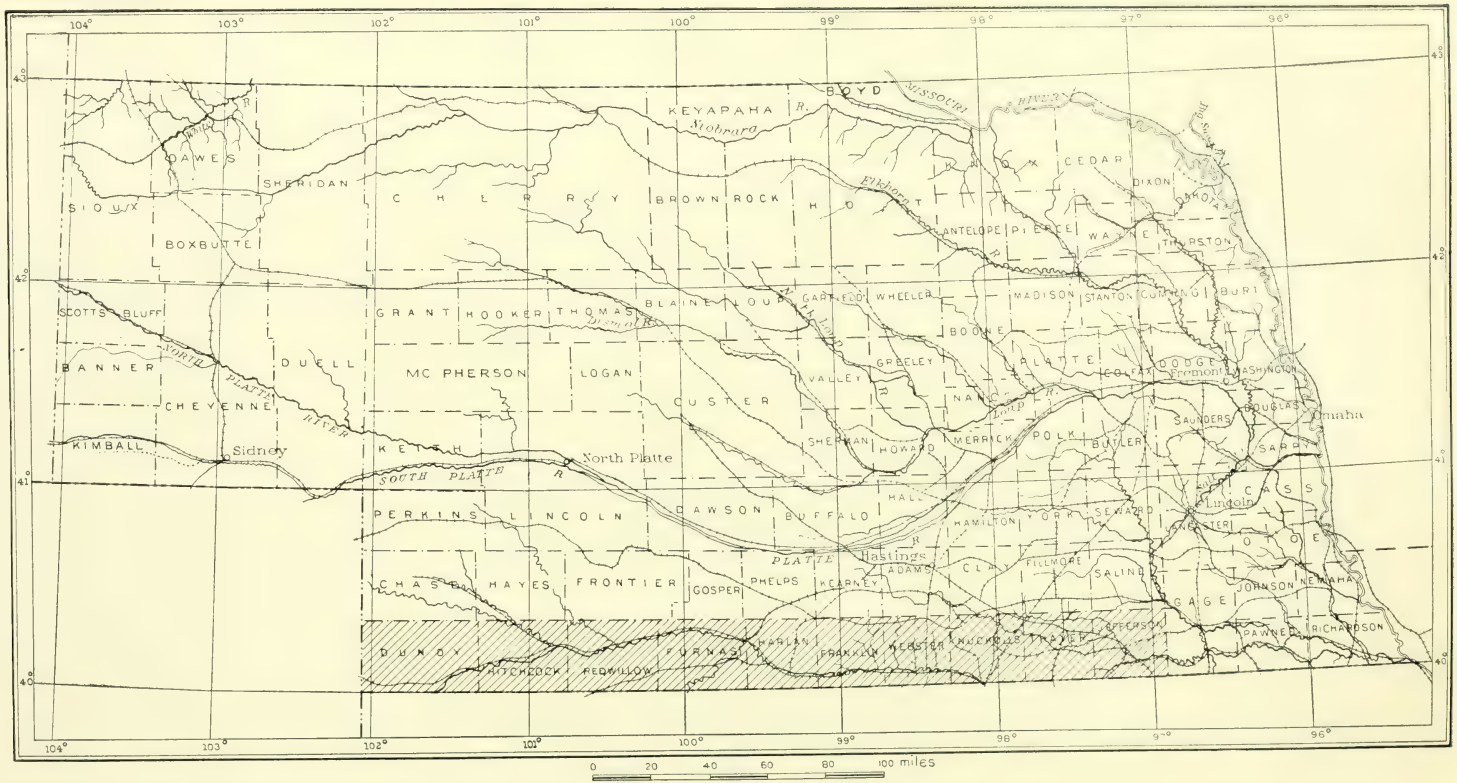



MAP OF NEBRASKA, SHOWING AREA TREATED IN THIS REPORT.

# GEOLOGY AND WATER RESOURCES OF REPUBLICAN RIVER VALLEY AND ADJACENT AREAS NEBRASKA.

By G. E. Condra.

## INTRODUCTION.

The region described in this report is the portion of southern Nebraska lying between latitude 40° and 40° 20′ and longitude 97° and 102°. It is 22¾ miles wide and 272½ miles long, and comprises an area of about 6,199 square miles. As shown in Pl. I, it includes the greater part of 10 counties, which are, from east to west, Jefferson, Thayer, Nuckolls, Webster, Franklin, Harlan, Furnas, Redwillow, Hitchcock, and Dundy. They lie along the Kansas border, extending from the vicinity of Fairbury westward to the Colorado State line.

This report is the result of general observations made during several consecutive seasons and of special field studies made by the writer under the direction of N. H. Darton during the summer of 1904. Considerable information concerning this region, collected by the Nebraska geological survey, has been furnished by Prof. E. H. Barbour. Numerous well records have been given by well drillers, business men, county superintendents, and teachers. The writer is also indebted to Messrs. U. G. Cornell, George A. Loveland, J. C. Stevens, E. N. Averill, N. J. Allen, and F. A. Carmony for valuable information.

Topographic maps are available for a portion of this area, the following sheets having been published by the United States Geological Survey: Hebron, Superior, Red Cloud, Holdrege, and Arapahoe. The topography for the remainder of the area has been compiled from barometer readings and railroad data.

## GEOGRAPHY.

### TOPOGRAPHY.

The area covered by this report is part of the Great Plains. It extends over portions of three fairly distinct physiographic regions—the high plains or table-lands, the loess plains or prairies, and the sand hills, each region possessing characteristic topography and drainage.

The general slope of the higher plains or upland surface is eastward from an altitude of about 3,600 feet in the western part of Dundy County to about 1,400 feet in the eastern part of Jefferson County, at an average rate of about 8 feet to the mile. The lowest altitudes are along the valleys in Jefferson County, being less than 1,250 feet south of Steele City. In most of the area, except in the sand hills, the topography has been developed by the action of running water, but in Jefferson County the great ice sheet of the Glacial epoch was an important factor in shaping the surface and developing its drainage.

The loess plains are relatively smooth and in greater part have practically no surface drainage, but where they are cut into by water courses there are deep canyons bordered by precipitous walls. Some of these canyons are long and deep, notably Trail Canyon, 4 miles east of Haigler, where there is a fall of 300 feet in a distance of less than 2 miles.

The sand hills, which are an outlying area of the great sand-hill region of Nebraska, extend from the north-central part of the State to its southwestern corner. The largest district treated in this report is in Dundy County north of Republican River and west of Rock Creek. The characteristic topographic forms are rounded sand dunes, sand ridges, blow-outs, dry valleys, and basins, with no run-off water except at the edge of the hills. Water often collects in some of the basins during the rainy season, forming small lakes.

### DRAINAGE.

The principal streams in the area are Republican and Little Blue rivers. The course of the former corresponds in direction with the general eastward slope of the country. Its bed lies 200 to 400 feet below the bordering uplands, and its valley slopes, though generally rough, vary somewhat in character from place to place, according to the varying nature of the geologic formations which the stream traverses. The valley itself and the valleys of the tributaries are generally wide and bordered by a definite system of terraces.

The valley of Little Blue River is nearly as wide as that of the Republican, but is somewhat shallower, and its direction is diagonal

to the general eastward slope of the surface. Near Powell it turns southward at right angles to its first course, a change possibly due to the former presence of the glacier in this vicinity.

## CLIMATE.

### TEMPERATURE.

The mean annual temperature in Jefferson County and in most of the region as far west as Hitchcock County is about 51°, but farther west it decreases to an average of 50°. The warmest month is July and the coldest January. East of Furnas County the number of days without frost during the year varies from 155 to 165. The latest frost of spring occurs between April 25 and May 1, and the first frost of autumn about October 1. In Furnas County and the remaining area to the west the average number of days without frost varies from 145 to 150. The latest frosts of spring occur between May 1 and May 5, and the earliest of autumn between September 25 and October 1.

### RAINFALL.

The average annual rainfall at eight stations is shown in fig. 1. The stations are located at regular intervals from east to west across the area, but the time during which records have been kept at the different stations varies in length from eleven to twenty-eight years. The heaviest rainfall is in May, June, and July, with light precipi-

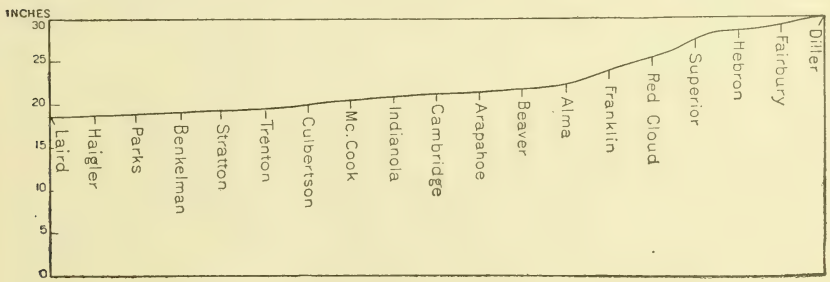



FIG. 1.—Diagram showing the decrease of mean annual rainfall from east to west in southern Nebraska.

tation during the winter months. The snowfall is slight, especially in Dundy County, but farther east it increases somewhat in amount. In the summer occasional hailstorms occur throughout the region, but are most frequent in the western portion, where they often do considerable damage to crops. Cloudiness is greatest in the east, giving way in the west to increasing sunshine and a lower degree of humidity.

*Normal precipitation, in inches, at eight stations in southern Nebraska.*

| Place. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fairbury | 0.75 | 0.74 | 1.63 | 2.75 | 4.74 | 4.61 | 4.80 | 3.13 | 2.45 | 2.38 | 0.79 | 0.63 | 29.40 |
| Hebron | .77 | .68 | 1.46 | 2.62 | 4.69 | 4.74 | 4.38 | 3.48 | 2.37 | 2.14 | .96 | .66 | 28.95 |
| Superior | .57 | .78 | 1.06 | 2.98 | 4.00 | 4.31 | 4.92 | 2.82 | 2.36 | 2.24 | .72 | .57 | 27.33 |
| Red Cloud | .33 | .59 | .77 | 2.27 | 3.32 | 4.75 | 4.30 | 2.73 | 2.77 | 1.81 | .59 | .51 | 24.74 |
| Franklin | .42 | .63 | .89 | 2.48 | 3.86 | 3.53 | 3.34 | 2.87 | 2.82 | 1.90 | .42 | .45 | 23.61 |
| Beaver | .25 | .62 | .77 | 2.48 | 3.18 | 3.90 | 3.60 | 2.28 | 2.03 | 1.14 | .54 | .41 | 21.20 |
| Culbertson | .37 | .63 | 1.05 | 2.36 | 2.76 | 3.56 | 2.94 | 2.74 | 1.52 | 1.05 | .36 | .36 | 19.72 |
| Haigler | .19 | .39 | .81 | 2.01 | 2.99 | 2.78 | 2.91 | 2.73 | 1.21 | .77 | .43 | .26 | 17.48 |

### WINDS.

No reliable data are available as to wind velocity, but the wind is generally stronger in the western counties than in those farther east.

## DESCRIPTIVE GEOLOGY.

### GENERAL RELATIONS.

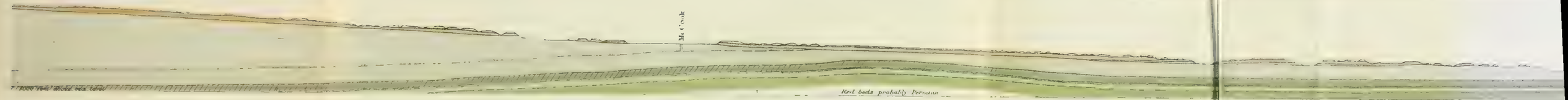
Southern Nebraska is underlain by various formations of Cretaceous age lying unconformably on Carboniferous formations and extensively overlain by Tertiary and Quaternary deposits; originally the latter covered the entire surface, but they have now been removed in the deeper valleys.

The relations underground of the Cretaceous formations have been revealed by deep well borings. They are of sedimentary origin, consisting of shale, sandstone, limestone, and chalk, and lie nearly level in a succession of widespread sheets. In the western part of the region they reach a thickness of 4,000 feet or more, but owing to erosion they thin out to the east. The Tertiary and Quaternary deposits consist of sands, loams, clays, bowlders, calcareous grit, and sandstone.

The formations outcropping in this area are as follows:

- Quaternary
  - Dune sands.
  - Alluvium.
  - Loess.
  - Drift.
- Tertiary
  - Ogalalla.
  - Arikaree.
- Cretaceous
  - Pierre.
  - Niobrara.
  - Benton:
    - Carlile.
    - Greenhorn.
    - Graneros.
  - Dakota.

U S GEOLOGICAL SURVEY




Vertical scale
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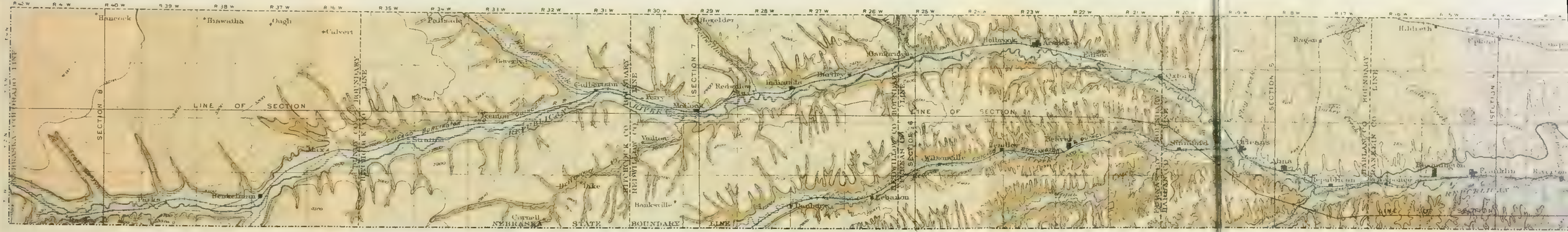



QUATERNARY

Dune sand

Loess and drift

TERTIARY

(Ogallala and Arikaree)

Eastern margin of Tertiary under loess (Approximate)

Pierre shale

Niobrara formation

CRETACEOUS

Carlile shale

Eastern margin of Carlile (Approximate)

Greenhorn

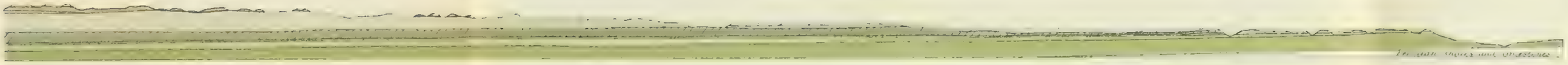
Base — Upper Pleistocene terrace,
Meeks, Smith & Schultz

# GEOLOGIC MAP OF REPUBLICAN AND LITTLE BLUE VALLEYS IN NEBRASKA

BY G. E. CONDRA

Scale

0 2 4 12 miles



CRETACEOUS

| | | | | | |
|---|---|---|---|---|---|
| urhle shale | Eastern margin of Carlile (Approximate) | Greenhorn limestone | Eastern margin of Greenhorn Approximate | Graneros shale | Dakota sandstone |

E VALLEYS IN NEBRASKA

les

The distribution and general structural relations of these formations are shown in Pls. II and III. The oldest is the Dakota sandstone, which underlies all of the region discussed, and is in turn underlain unconformably by Permian limestones and shales which outcrop extensively farther east in Nebraska and southeast in Kansas. The overlying formations occur in regular order, but do not extend over the entire area.

## STRUCTURE.

In southern Nebraska the rocks lie nearly horizontal, but, as shown in the section on Pl. II, with a general westerly inclination, interrupted near Cambridge by a low uplift or arch discovered by Mr. Darton several years ago. This arch develops in northwestern Kansas and extends northwestward across Nebraska. Its configuration is defined by the relations of the Niobrara formation, which is uplifted 200 feet or more near the crest of the arch in the vicinity of Cambridge. From the crest the Pierre shale and 100 feet or more of the Niobrara have been eroded in the central and western portions of Furnas County. On the west side of the anticline the strata dip westward at an unknown but moderately rapid rate, so that in the extreme southwestern corner of Nebraska the top of the Niobrara formation is at a depth of about 2,000 feet, judging by the structure in adjoining portions of Colorado. East of the anticline there is a shallow syncline which holds Pierre shale from Arapahoe east to Naponee; thence eastward the strata rise gradually, and formations from Niobrara to Dakota outcrop in regular succession in the counties from Franklin to Jefferson. In general the rate of inclination is regular and averages 3 feet in a mile. Locally, however, the rate is very much increased, especially in portions of Jefferson County. A local flexure is presented by the Greenhorn limestone in the southern portion of Jefferson County, and steep local dips of 10° or more occur to the southwest, in the exposure of Dakota sandstone south of Thompson, Nebr. The Dakota formation presents also a low anticline in the vicinity of Thompson and Gladstone, with the upper part of the arch removed by erosion. Faults, showing a few inches of displacement, occur in the Niobrara chalk in a number of places, one of the best defined examples being at Norton in beds dipping gently westward. This fault is shown in Pl. IV, *B*.

## DESCRIPTION OF THE ROCKS.

### CARBONIFEROUS SYSTEM.

A short distance east of Jefferson County Permian limestones and shales—the upper series of the Carboniferous system—rise from

beneath the Dakota formation and appear in many outcrops. They undoubtedly underlie the area treated in the report but at increasing depth to the west, and it is possible that they immediately underlie the alluvium in the vicinity of Diller and along the Little Blue River Valley below Steele, where they are known to come close to the surface. The following is a typical section of the Permian beds which pass under the Dakota sandstone in southeastern Nebraska:

*Section at the J. P. McAllister quarry, 1 mile southeast of Odell.*

| | Feet. |
|---|---|
| Limestone, fossiliferous, weathered | ⅔ |
| Clay, light buff | 4 |
| Limestone, grayish, but rusty at places, massive, even grained, with few fossils; used for building stone | 1½ |
| Clay, buff colored | 4 |
| Clay, ocherous, reddish to brownish | 12 |
| Limestone, clayey, decayed | 5 |
| Limestone, flinty | 1½ |
| Clay and decayed limestone, exposed in ravine | ? |

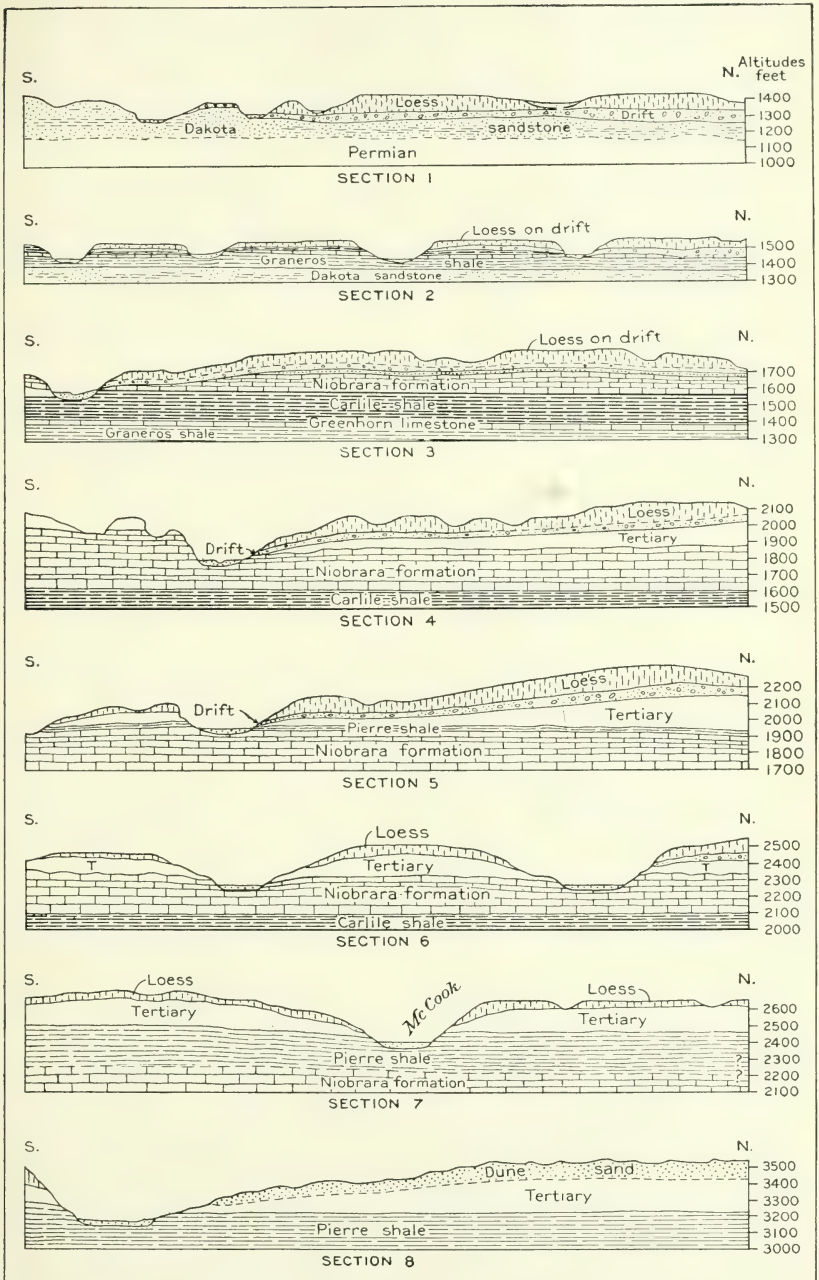
In eastern Nebraska the upper surface of the Permian rocks was a land surface in early Mesozoic time, while in the Rocky Mountain region west there was deposition of early Cretaceous, Jurassic, and Triassic sediments. Possibly some of these reach the western portion of the area treated in this report, but of this there is no evidence.

## CRETACEOUS SYSTEM.

### DAKOTA FORMATION.

*Character and thickness.*—The Dakota formation in this region consists of sandstone and clay, with the former generally predominating. While the formation as a whole shows considerable variation in stratigraphy, in most localities it is possible to recognize three members—a basal sandstone member, a medial clay member, and an upper sandstone and shale member. The lower sandstone is a medium to coarse grained variety, occurring in beds which are usually massive and cross-bedded, although in places thin bedded. Its color is gray or pale buff, but on exposed surfaces it is generally rusty brown, and portions of it are often stained to a deep brown. The clays are variegated, with red and green predominating. In some places they are more or less sandy, and thin beds of relatively pure sandstone are not infrequent. The clay is overlain by a massive, cross-bedded, dark-brown sandstone, which constitutes the upper member of the formation. This sandstone sometimes contains concretionary masses which are lighter colored and more compact than the remainder of the rock. Associated with the sandstones of the upper part of the formation are thin beds of impure lignite coal.

The Dakota formation south of Kesterson is about 275 to 300 feet thick, but the beds may thicken somewhat to the west. It is overlain




SECTIONS ACROSS SOUTHERN NEBRASKA ALONG VERTICAL LINES SHOWN ON PL. II.

conformably by the Graneros shale and unconformably by Quaternary deposits. It rests upon the eroded surface of the underlying Permian, as is indicated by the differences in altitude of the base of the formation. Many species of well-preserved fossil leaves of Upper Cretaceous age have been found in the Dakota sandstone, especially in Jefferson County. A section near Steele is as follows:

*Section of Dakota formation in slopes west of Steele.*

| | Feet. |
|---|---|
| Sandstone, brownish, usually massive | 40–60 |
| Clay, light buff to ocher yellow | 80–110 |
| Sandstone, rusty, massive | 40–55 |

*Distribution.*—The Dakota formation is extensively exposed in Jefferson County, in the eastern part of the region, where it outcrops in an area of varying width, extending across the southern townships of the county westward to a point about 6 miles west of Reynolds, where, with low westerly dip, it passes beneath the overlying formations. It is also exposed along the Little Blue River Valley from Fairbury to a point due north of Gilead, and it extends up Big Sandy Creek to Alexandria. It outcrops in the vicinity of Diller, and a small area of it is exposed along the valley of a small stream about 3 miles southeast of Plymouth. The distribution of the formation is shown on the geologic map (Pl. II, p. 10) and some of its features are shown in Pl. IV, *A*.

## BENTON GROUP.

### MEMBERS REPRESENTED.

It has been shown by Mr. N. H. Darton that in southern Nebraska the formation formerly called Benton consists of three distinct members, which represent the Graneros shale, Greenhorn limestone, and Carlile shale of the Rocky Mountain region. Their combined thickness here is about 270 feet to the east and 650 feet or more to the west.

*Generalized section of Benton group in southern Nebraska.*

| Formation. | Character of materials. | Thickness. |
|---|---|---|
| | | *Feet.* |
| Niobrara | Chalkstone | |
| Benton: | | |
| Carlile | Bluish, plastic clays containing a horizon of concretions near middle; iron pyrite and selenite crystals occur throughout the clay. | 75 |
| | Dark-colored shales and clays with thin beds of fossiliferous limestone, containing large numbers of *Ostrea congesta*. | 75 |
| Greenhorn | Limestone layers, cream colored and fine grained; they contain fish remains and are interbedded with light-colored, plastic clay. | 1½ |
| | Limestone layers interbedded with clay in strata of uniform thickness, containing *Inoceramus labiatus* in great abundance. | 10 |
| | Limestone layers, fine grained, light colored, interbedded with clay; darker, more impure, and porous below. | 16 |
| Graneros | Clay and shale, mostly dark gray, containing carbonaceous and sandy beds near middle. | 70 |
| Dakota | Sandstone and sandy shales | |

### GRANEROS SHALE.

*Character and thickness.*—The Graneros shale, or lowest division of the Benton group, consists in this region of dark-colored, plastic clays and shales. Near the middle of the formation occur beds of dark carbonaceous shale which closely resemble an impure variety of coal. Just below this shale and at the base of the formation the shales are usually sandy. Large sandstone concretions abound, some of which are fossiliferous. The shales contain a large amount of iron pyrite which, by weathering, changes to melanterite, a compound which readily dissolves in water.

In its outcrop area the thickness of the Graneros varies from 40 to 70 feet, but this amount probably increases to the north and west, for the formation has a thickness of 900 feet in the Black Hills region and over 200 feet in central Colorado. It lies conformably upon Dakota sandstone and is overlain in turn by harder beds of Greenhorn limestone. It is often difficult to sharply define the lower limits of the formation, owing to the similarity between the sandy shales at the base of the Graneros and those in the upper part of the underlying Dakota. The upper limit of the formation is clearly indicated by an abrupt change in the character of the sediments.

The following section indicates the character and succession of the beds near Fairbury:

*Section of Graneros shale and associated formations 5 miles northwest of Fairbury.*

| Formation. | Character of materials. | Thickness. |
|---|---|---|
| | | *Feet.* |
| Greenhorn | Limestone alternating with beds of clay. The limestone contains *Inoceramus labiatus* in great abundance. | 25 |
| Graneros | Dark-colored shale and clay, containing thin beds of limestone | 55 |
| Dakota | Sandstone, medium grained, rust colored, with white and variegated clays below. | 60 |

*Exposures.*—The Graneros shale is exposed in the eastern part of the district, mainly in Jefferson County, although exposures are found in Thayer County along Rose and Big Sandy creeks and Republican and Little Blue rivers. The most extensive exposures are in the bluffs south of Hubbell; in a small ravine on the north side of Little Blue River, southwest of Alexandria; and beneath the limestone capping slopes 4 or 5 miles northwest of Fairbury.

### GREENHORN LIMESTONE.

*Character and thickness.*—The Greenhorn limestone, or middle formation of the Benton group, consists of limestones and clays in alternating succession. The limestones, which predominate, are soft,

*A.* DAKOTA SANDSTONE EAST OF ENDICOTT, NEBR.

*B.* NIOBRARA LIMESTONE NEAR NORTON, KANS., SHOWING SMALL FAULT.

light colored, and fine grained, and occur in beds ranging in thickness from 3 to 10 inches, the average being about 6 inches. They are usually fossiliferous, containing layers with many remains of *Inoceramus labiatus*, which is characteristic of the formation. The clays are light colored, plastic, and are in beds rarely exceeding a few inches in thickness.

The formation ranges from 25 to 30 feet thick and generally exhibits four limestone and clay members, which in regions to the south, owing to their distinctive characters, have been given local names by the Kansas geologists. The lowermost member, which in northern Kansas is a hard, dark-grayish limestone, is locally known there as the Lincoln marble. The individual beds of this member are about 8 inches thick and the total thickness is approximately 15 feet. Above the Lincoln marble there are several thin layers of white limestone interbedded with clay and having a total thickness of 10 feet, which are known as the Flagstone member. The next member consists of somewhat darker colored limestones containing many *Inocerami*, and for this reason it has been designated the *Inoceramus* member. It is 4 to 5 feet thick. The top member consists of one limestone layer about 9 inches thick, which has been called the Fencepost limestone owing to its extensive use for fence posts throughout the region.

These members of the Greenhorn formation are not so distinct in the region to which this report relates as they are in areas farther south, but they are all recognizable. In the excellent section south of Hubbell the lowermost division includes the equivalents of both the Lincoln marble and the Flagstone member, the middle division the *Inoceramus* member, and the uppermost division the Fencepost member. The *Inoceramus* member appears to be somewhat thicker in Nebraska than in Kansas. The Lincoln marble is well exposed in a cut bank along Little Blue River northwest of Gilead, where its thickness is about 15 feet.

The part of the Greenhorn limestone which is quarried appears as a light-colored streak high in the slopes in Jefferson County and in the lower parts of valleys in the eastern part of Thayer County. At a quarry 4 or 5 miles northwest of Fairbury the exposures are at an altitude of slightly less than 1,500 feet. Along the river north of Gilead the altitude of the formation is from 1,460 to 1,490 feet. Southwest of Endicott the base of the formation has an altitude of about 1,525 feet. The beds quarried south of Kesterson have an altitude of 1,535 feet, while at Hubbell they are at about 1,505 or 1,510 feet. Westward along Rose Creek Valley the beds gradually sink from high in the slope and reach the level of the valley bottom between Hubbell and Chester. These facts indicate that the formation dips gently to the northwest except for a

small local flexure in the southern part of Jefferson County. Where present at the surface the limestones form a ridge or escarpment in the valley slopes, below which the underlying Graneros shale is marked by a clay slope.

*Fossils.*—*Inoceramus labiatus*, which characterizes this formation, occurs in large numbers in most of the beds. The formation has also yielded several specimens of fossil fish, and Dr. G. A. Birdsall, of Alexandria, has collected vertebræ and bones of various kinds from quarries north of Gilead. Mr. C. A. Carmony obtained, south of Kesterson, a large ammonite, which is now on exhibition in the State Museum of the University of Nebraska. The best specimens of fish remains are found in the fine-grained limestone layers near the top of the formation.

### CARLILE SHALE.

*Character and thickness.*—The Carlile shale, the uppermost formation of the Benton group, consists of dark-colored clays and shales, which, in Kansas, have been separated into two members. The lower, which is the more calcareous, carrying thin beds of fossiliferous limestones, has in that State been designated the *Ostrea* horizon, on account of the presence of large numbers of *Ostrea congesta*, while the upper, which is composed of bluish, plastic clays, with fewer fossils, has there been designated the "*Septarian* zone" or Blue Hill beds. Near the middle of this upper member is a horizon of biscuit-shaped concretions, which is well exposed in the vicinity of Lovewell, Kans. These concretions are often traversed by cracks filled with calcite, selenite, and occasional crystals of barite. They are generally large, some exceeding 6 feet in diameter. Throughout the formation and especially in its upper part there are large quantities of iron pyrite, which decomposes to sulphate of iron, or melanterite, a mineral which appears on the surface as a light-colored powder of acrid taste. By chemical reaction the decomposing pyrite in the clay banks also forms calcium sulphate, which crystallizes as selenite, and crystals of this mineral are usually scattered over the surface in great abundance.

The exact thickness of the formation is believed to be over 200 feet in Nuckolls County and westward, but owing to erosion of its upper surface it thins out in Jefferson County along an eastern margin shown on the map (Pl. II).

*Exposures.*—The Carlile shale is not extensively exposed in the area included in this report, but it outcrops at intervals along the valleys of Republican and Little Blue rivers and Rose Creek. It usually appears on the slopes as a narrow band overlain by loess and resting upon greenhorn limestone. Along the south margin of the district

it is exposed as an area of irregular width capping the higher land from a point nearly due south of Kesterson to near where Republican River crosses the State line.

### NIOBRARA FORMATION.

*Character and thickness.*—The Niobrara formation in southern Nebraska consists principally of a chalky limestone known as chalk rock, with interbedded layers of calcareous clay and local deposits of flint. The prevailing colors of the rock are lead gray, light gray, and yellowish, depending on the degree of weathering. Much of the weathered rock is straw yellow, and in certain localities is ocherous in color; in the bluffs south of Guide Rock, where the weathered portions of the rock are rapidly removed by erosion, it is lead gray with a decided bluish tint. The chalk rock has a porous texture and gives a hollow sound when struck with a hammer. It has an uneven fracture and a tendency to break into splinter-like forms. It varies considerably in composition from place to place, the principal impurities being clay, silica, and gypsum. Where clay is present in large amounts the beds are usually shaly.

In previous descriptions of the geology of this portion of Nebraska, no subdivisions were made of the Niobrara formation, which was described as consisting mainly of soft limestone chalk rock, or limy clays, presenting considerable variation from place to place. It has been found, however, that it comprises two distinct members, a lower and an upper, which are probably equivalent, respectively, to the Fort Hays beds and the Smoky Hill chalk of Kansas. The total thickness is about 400 feet. Some features of the formation are shown in Pls. IV, *B*, and VIII, *A*.

The basal member of the Niobrara consists of massive soft chalky limestones, bluish to light gray on freshly broken surfaces, but weathering to yellowish. The thickness of this member varies from 40 to 50 feet and the outcrops are usually marked by more or less prominent ledges capping the softer shales of the underlying Carlile formation. Extensive exposures of these beds occur on the south side of Republican River between Superior and Bostwick, and along Whiterock Creek in Kansas.

In southern Nebraska the upper member of the Niobrara formation is about 300 feet thick. It consists of a bluish-gray chalk, generally massive and irregularly jointed, with layers of light-colored limestone and calcareous clays distributed throughout. The beds in the upper part vary considerably in character in different localities. Wherever the formation is overlain by Pierre shale the chalky beds continue to the top of the formation, but in a wide area in the vicinity of Cambridge, and in the southern part of Nuckolls County, where

the Pierre is absent, the upper beds of the Niobrara are ocherous and more or less flinty. The flint is brownish, reddish, or greenish in color; it occurs in continuous beds in the top of the formation, but lower down in scattered nodules; the beds vary in thickness from a few inches to 10 feet, and it is believed that they have accumulated in the chalk subsequent to its deposition, probably during late Tertiary or Quaternary times.

*Fossils.*—Fossils are very abundant in the Niobrara formation. *Ostrea congesta* and a large flat *Inoceramus* are the most common forms, the former often attached to fragments of the latter. Well-preserved fish remains are not infrequent, and turtles have been collected in the vicinity of Cambridge. The chalk rock, when examined closely, is found to be composed largely of minute shells which grade in size from those plainly visible to the unaided eye to microscopic forms.

*Distribution.*—The Niobrara formation has a relatively wide outcrop area in central-southern Nebraska. It first appears under the loess in isolated areas in the valley of Little Blue River and its tributaries above Angus, at Nelson in the central part of Nuckolls County, and farther south on either side of Smyrna and near Bostwick. The formation outcrops most extensively along Republican River and its tributaries, rising high on the slopes south of Guide Rock. Westward it gradually falls to lower levels on the slopes, until, in the vicinity of Republican, its exposures are principally limited to the lowlands of the valley. At Edison the Niobrara outcrops narrow somewhat, and the Pierre shale occupies a portion of the bottom lands on either side, but to the west it widens again, retaining a nearly uniform width to the point where it passes beneath the Pierre shale south of Indianola. In the low valley land along Republican River the Niobrara formation is generally covered by Quaternary deposits. At Riverton, Republican, and south of Orleans the alluvial deposits have been removed, exposing the chalk rock in the banks of the river. The Niobrara occupies the lowlands of Beaver Creek Valley from its mouth westward to near Danbury, and along Sappa Creek, its main tributary, to beyond the Nebraska-Kansas State line, but it is nearly always covered by a thin deposit of alluvium. The eastern margin of the formation under the loess is near the east line of Nuckolls County. The details of the distribution of this formation are shown on the geologic map, Pl. II.

### PIERRE SHALE.

*Character and thickness.*—The Pierre shale, as exposed along the Republican Valley in southern Nebraska, consists mainly of plastic, loose-textured, carbonaceous clays which become shaly on weathered

surfaces. The clays are unctuous when moist and hence are popularly known as soapstone. The common colors are dark bluish to black, with many rust-colored spots. Gypsum crystals are distributed throughout the shales, weathering out in great abundance on the barren slopes, and iron pyrites are found in thin layers at many horizons. The pyrite decomposes readily, and much of the resulting product is scattered over the surface as irregular fragments of iron oxide. The maximum thickness which the formation reaches in the western part of Dundy County is not known, but apparently it is more than 1,000 feet. No reliable well records could be obtained to show the thickness underground, but the formation is known to thicken rapidly to the west and north, reaching 7,700 feet west of Denver. In the syncline between Arapahoe and Naponee it has a thickness of 50 feet or more and thins out to the east and the west. A well-defined layer in the Pierre shale in this region consists of a carbonaceous shale resembling an impure coal in some respects. This layer has a thickness of about 25 feet, and is well exhibited along the Republican from near the Alma bridge to beyond Orleans. The shales of this member are least plastic near the top and erosion often develops buttresses and recesses in them. The bedding and jointing are fairly distinct, and many layers and joint seams contain gypsum as a yellowish powder. Overlying this carbonaceous member are dark-bluish clays, with well-defined bedding, but fewer joints. In Dundy County the upper part of the exposed Pierre for 10 to 12 feet are of yellowish color. The Pierre shale contains a few fossils, such as *Baculites compressus* and small ammonites.

*Distribution.*—The Pierre shale rests conformably on the Niobrara and is overlain unconformably by Tertiary deposits (see Pl. V, *B*). It is exposed along the Republican and its tributaries from the western part of Franklin County to the vicinity of Arapahoe, and from near Indianola to the west line of the State. It also extends for some distance up Prairiedog Creek to beyond the Nebraska-Kansas line, and up Sappa and Beaver creeks into the eastern margin of Furnas County. It reappears in the valley of Sappa Creek a short distance above Lebanon and continues to beyond the State line.

### TERTIARY SYSTEM.

The Tertiary deposits of southwestern Nebraska appear to belong entirely to the later epoch of that system but they have not as yet been definitely classified. Apparently the principal formation corresponds to the Ogalalla of Darton, but possibly to some of the Arikaree as well.

*Character and thickness.*—The Tertiary deposits consist mainly of sand, gravel, and clay, in places bound together by calcareous cement

into beds of variable hardness. Their character varies greatly from place to place. The sands are mostly medium to fine grained, often grading into a coarse cross-bedded sand and gravel. The gravel is waterworn and varies in size from small pebbles to bowlders 4 to 6 inches in diameter. (See Pls. V, *C*, and VI, *B*.) The materials comprise quartz, feldspar, granite, andesite, and porphyry, apparently derived from the Rocky Mountins. The clays are usually sandy, sometimes becoming so fine grained as to be a silt or loam. Deposits of this character occur north of Max, where there is much clay or loess-like silt, but in general the greater part of the sediment consists of sand and gravel irregularly mixed and often imperfectly stratified. Volcanic ash is generally associated with the sand beds and it occurs in lens-shaped deposits or beds in a number of places. The usual color of the ash is light gray and it is medium to fine grained. Opalized wood is scattered over the surface at various places in the Tertiary outcrop, notable localities being southeast of Laird and at the head of Rock Creek. At a few places in the western counties the calcareous cement occurs in sufficient amount for use as a natural plaster. A partial section of the Tertiary beds, as exhibited southeast of Franklin (see Pl. V, *A*), is given below:

*Section at Lookout Mountain southeast of Franklin, Nebr.*

| | Feet. |
|---|---|
| Limy sand rock, texture varying; color gray to white | 10 |
| Sand, light colored on surface, fine grained, at places lithified | 10 |
| Quartzite, light to olive-green color; texture variable, but usually medium grained; siliceous cement | 1½ |
| Sand of various colors and medium grained | 30 |
| Chalk rock (Niobrara); colors, yellowish at top, whitish and bluish gray below | 200 |
| | 251½ |

*Distribution.*—The Tertiary deposits are exposed along the south side of Republican Valley from a point south of Red Cloud to Edison, and thence westward to the Nebraska-Colorado line along both sides of the valleys of the Republican and its principal tributaries. They are also exposed along Beaver and Sappa creeks and their numerous small branches throughout their entire extent within the area. The formation lies on the uneven surface of the Pierre (see Pl. V, *B*) and Niobrara formations, and is in turn extensively overlain by loess and other Quaternary deposits.

## QUATERNARY SYSTEM.

### DRIFT.

The greater part of Nebraska is covered by a thin but widespread sheet of sands and gravels, transported to the region by glaciers from the north and by streams from the west during Pleistocene

*A*. LOOKOUT MOUNTAIN, SOUTHEAST OF FRANKLIN, NEBR., SHOWING BLUFFS CAPPED BY TERTIARY SANDY LIME ROCK.

*B*. TERTIARY "MORTAR BEDS" ON PIERRE SHALE EAST OF HAIGLER, NEBR.

*C*. TERTIARY GRAVEL NEAR HEAD OF TRAIL CANYON, DUNDY COUNTY, NEBR.

time. The glacial deposits have been called northern or glacial drift, and the stream deposits western drift. The glacial drift occurs only in the eastern part of the region treated in this report—that is, in Jefferson County and the eastern part of Thayer County—but it extends north across eastern Nebraska. The greater part of the material is till with scattered deposits of bowlders, and it is more or less overlain by loess, especially to the west, where its margin is hidden by the loess. The sands and gravels of western origin extend westward under the loess, and in Jefferson County, especially along the Little Blue, appear to merge into the glacial drift, but the contact relations are not clearly exposed.

The glacial drift in Jefferson and Thayer counties lies unconformably on the Dakota, Graneros, Greenhorn, and Carlile formations, and in places, especially on the uplands, is covered by loess. The glacial sands and gravels at Fairbury appear to be older than much of the clayey till in eastern Nebraska. They are separable at places into two members, an upper rusty-colored one and an underlying lighter colored and locally more regularly stratified member. These two show best in the sandpit of the Rock Island Railroad, about 4 or 5 miles northwest of Fairbury. Bowlders and pebbles occur in both divisions, but they are more noticeable in the upper one, perhaps because this is the more exposed and eroded.

A thin bed of brownish to yellowish clay till caps the glacial sands in the uplands about Fairbury, coming as low as 1,370 feet in altitude, but usually not much below the 1,380-foot level. It increases in thickness eastward in the direction of Jansen, Plymouth, and Lincoln. This clay contains pebbles and bowlders, usually of pinkish quartzite. It rises to an altitude of 1,430 feet 1 mile northeast of Jansen and to about 1,400 feet in the vicinity of the Chicago and Rock Island Railroad bridge across Cub Creek, at which place about 40 feet are exposed. In a railroad cut just west of this bridge the till is separable into two divisions. The lower, 12 feet of which rise above the level of the track, is sandy and concretionary, with few pebbles and bowlders; of the upper, about 11 feet of typical yellowish, pebbly, and bowldery clay are exposed in the cut, and it rises still higher in the hill slope. This member of the drift is distinct from the loess, by which it is covered to a depth of 30 to 45 feet at Plymouth.

Concretions often occurring in the till are composed of calcium carbonate. They range from 1 inch to more than 4 inches in diameter.

In general, there are two fairly distinct members of the glacial drift in Jefferson County, as shown by a section between Fairbury and Plymouth, both containing bowlders and both showing smaller local divisions. Small deposits of clay have been observed to occur in

the sand and gravel. Clay which may prove to be of glacial origin is found along the Chicago and Rock Island Railroad southwest of Thompson, and even as far west as Nelson.

The vertical range of glacial bowlders and till is from altitudes of 1,250 to over 1,500 feet. The exposed bowlders are confined to Jefferson County, with a few in Thayer County. They occur for the most part east of Little Blue River, but extend 2 to 4 miles west of that river, between Powell and Steele, and to only a few miles south of Rose Creek. They come to the surface where the loess and finer parts of the till are eroded, and in some places they become abundant. The largest area of this kind is located just southeast of Endicott, where bowlders, mostly of Sioux quartzite, with a relatively small number of granite, cover nearly 2 square miles of the Dakota escarpment and adjoining slopes (see Pl. VI, *B*). These bowlders have been concentrated from till by the removal of the sand and loam by erosion. In the greater part of Jefferson County east of the river bowlders usually occur beneath the loess cap, and where the loess has been eroded the bowlders and other coarser glacial materials are brought to view. Other bowlder areas occur near Steele, Fairbury, and at a number of places in Cub Creek Valley. A large quartzite bowlder northeast of Fairbury, $4\frac{1}{2}$ by 9 by 10 feet in size, is shown in Pl. VI, *A*. Another of coarse-grained granite, $4\frac{1}{2}$ by $6\frac{3}{4}$ by 17 feet in size, is located in a gravel bench one-half mile away; its size has been reduced by blasting. The glacial bowlders comprise Sioux quartzite, granites, syenites, gneiss, hornblendic and mica schists, flinty limestone, Dakota sandstone, and Greenhorn limestone. Some of these were carried long distances by ice, while others came from ledges not distant. The granitoid rocks are rounded in part by weathering, but most of the quartzites are angular and little worn.

It appears that the presence of the ice sheet in Jefferson County affected the drainage over wide areas westward, causing the rivers to fill up their valleys and then to spread sediment over the general region along and to the west of the glaciers. The deposits of western drift are found as far west as Arapahoe, Cambridge, and Trenton. That this deposit is of western origin is proved by the presence of a large amount of typical Rocky Mountain rock. Much of it, however, came from Tertiary formations which were derived from the Rocky Mountain region.

Remains of the primitive elephant have been found in the Fairbury gravels.

All of the glacial drift in the region treated in this report is generally known as the Kansan drift. A part of it may be of Aftonian age.

*A*. QUARTZITE BOWLDER NORTHEAST OF FAIRBURY, NEBR.

*B*. GLACIAL BOWLDERS SOUTHEAST OF ENDICOTT, NEBR.

### LOESS.

This formation constitutes the surface of the greater part of southeastern Nebraska and adjoining regions. Originally it covered the entire surface, but it has been cut through by the larger streams and now remains on the wide plateau areas between the valleys. The typical loess is characterized by its fine, even-grained, massive structure, porous texture, light-buff color, and the presence of a weak calcareous cement. It is often called the "bluff" deposit where deep canyons and river bluffs are formed of it, because, owing to its massive structure, it weathers into steep slopes. The well drillers speak of it as "yellow clay." The loess generally lies directly upon glacial drift or the western gravel deposits, but also overlaps on the older formations. Its thickness on the high loess plains is about 100 feet. The formation has a strong tendency to vertical displacement in canyon walls and bluffs, so that on many slopes it settles or creeps over the edges of the underlying formations, concealing them from view. Where eroded by running water it stands in nearly vertical banks. On account of its massive structure and coherent nature, many wells bored in the loess region do not require casing in the part penetrating this formation. Ordinarily cellars in loess do not require to be walled.

The loess varies noticeably in color and somewhat in texture in different parts of the region, varying from light buff to brownish, a difference apparently related to the underlying beds, for the color is lightest where the loess overlies the light-colored Niobrara chalk rock and darkest when on or near the ocherous Niobrara and the Dakota formation.

The loess consists principally of silt and clay particles loosely cemented by carbonate of lime and stained by a small amount of iron oxide. The proportion of each of these ingredients varies from place to place. The silt grains increase in size and proportionate amount from east to west and apparently also with depth. The upper surface of the loess is darkened by humus and grades into the cultivable soil.

The mode of accumulation of the loess has been a subject of much discussion. According to the earlier view it is a wind-blown deposit, while according to a later view it was deposited over a wide extent of country by low-grade streams at the close of the Pleistocene; probably both of these agencies have been factors in its origin.

It contains numerous fossil shells, mostly gasteropods, of freshwater nature.

### TERRACE DEPOSITS.

Terraces are conspicuous along Republican River and Beaver, Sappa, and Prairiedog creeks. They are locally known as benches,

or as second and third bottom lands. Their heights in the Republican Valley are mostly 6 to 14, 25 to 40, and from 60 to 80 feet above the first bottom. Low benches are clearly defined in the vicinity of Haigler. At Oxford they are from 6 to 8 feet high. The terrace extending along the south side of Republican River from Amboy to a point southwest of Superior is 25 to 30 feet high. Four miles west of Benkelman a high terrace rises about 75 feet above the river. At several places in Dundy County and in the western part of Hitchcock County the wind has eroded the terraces into dune-sand topography, as illustrated in Pl. VII, *B*. Terraces on the south side of Republican River are less continuous than those on the north, owing mainly to the fact that the river crowds the right bank at places and has entirely removed the benches.

The terraces are capped by an alluvial deposit resembling somewhat the loess in texture, but showing more definite stratification and greater variation in the size of the component parts. The material in the high terraces in Dundy and Hitchcock contains a large amount of silt and in many respects resembles the loess to the west. It contains remains of the primitive elephant and the mastodon. Bones of *Elephas primigenius* were found by Mr. Max in the terrace deposits just north of the town of Max; other remains of this species have also been collected from these beds along Driftwood Creek 12 miles south of Trenton and at several other localities in the region.

### ALLUVIUM.

A relatively thick deposit of alluvium occupies the floors of all the principal valleys and their tributaries throughout this portion of Nebraska. It generally consists of sand, gravel, and clay which shows considerable variation in character in different parts of the region.

The thickness of the deposit varies from 20 to 80 feet, the average being about 50 feet. The broader areas of alluvium are composed of fine sand near the surface, with medium to coarse gravel below, and in most localities beds of clay of variable thickness have been encountered by well drillers. Along the smaller tributaries the alluvium varies greatly in amount and character, according to the nature of the formations from which the material is supplied. The smaller streams traversing Tertiary, Dakota, or Pleistocene formations usually contain much alluvial sand and gravel, while those flowing over only Niobrara and Benton formations have but little alluvium along their course, for the materials, being fine-grained, are usually transported at flood times to the larger stream courses, leaving the bed rock uncovered. At Fairbury, along Little Blue River, the alluvial bottom land is from $\frac{1}{2}$ to 2 miles in width. The depth of the deposit is not definitely known, but it has been penetrated to reported depths

*A*. TERRACES NEAR MOUTH OF TRAIL CREEK, DUNDY COUNTY, NEBR.

*B*. WIND EROSION IN HIGH TERRACE WEST OF BENKELMAN, NEBR.

of 60 to 80 feet. In this region it is composed of medium to coarse sand, gravel, and clay, with a small proportion of decomposed organic matter.

#### DUNE SANDS.

In the western part of Dundy County, northeast of Haigler, the Tertiary sands have been blown by winds into hills and ridges, with intervening dry valleys and basins forming a typical sand-hill region, as shown in Pl. VIII, *B*. In some places along the Republican, as far east as Trenton, the high, silty terrace has been more or less eroded by the wind, forming blow-outs and dunes. In places the dune sands are encroaching on the river. The veneer of sand is thin, and has been largely derived from the Tertiary materials and high-terrace deposits. Small terrace dunes are also found along the sandy bottoms of Little Blue River near Fairbury and at numerous places along the Republican.

## ECONOMIC GEOLOGY.

### MINERAL RESOURCES.

The region to which this report relates possesses various mineral resources, some of which are sufficiently valuable to warrant development.

#### COAL.

Prospecting for coal has been in progress throughout the region since the time of earliest settlement. Three carbonaceous horizons, each in a different formation, have seemed promising to prospectors.

The first is in the upper part of the Dakota formation, where thin beds of impure lignite occur. During 1903 a small amount of this coal was mined three-quarters mile east of Powell, Jefferson County. The thickest bed at this place is about 7 inches and it outcrops in a ravine north of Little Blue River. Thin beds of lignite probably occur in many parts of the Dakota formation throughout the region, but there are few outcrops, and it is doubtful if the material ever reaches a workable thickness. Coal is mined to some extent from the Dakota formation at a few localities in Kansas, south of Thayer and Nuckolls counties, and the same amount and quality of coal that is worked in Jewel County, Kans., is believed to extend to the vicinity of Hardy and Superior, Nebr., but the depth at which it would be reached then entirely precludes the possibility of working it successfully.

The second carbonaceous horizon lies above the Dakota in the Graneros shale, the lowest division of the Benton group. The rock of this horizon outcrops at several places in Jefferson County, where it has been prospected extensively, but without success.

The third carbonaceous horizon referred to is in the lower part of the Pierre shale. It has been prospected more or less in the region between Republican and Arapahoe, also south and west of Orleans, but offers no encouragement whatever of affording true coal or lignite.

### PETROLEUM AND NATURAL GAS.

While there are no grounds for believing that petroleum and gas may be obtained by borings in the Republican Valley region, these materials may possibly occur, and the possibilities are such as to warrant more complete and detailed investigation. There are no surface indications of oil and the only gas reported is a small amount in a well 405 feet deep at McCook. This well yields a flow sufficient to afford a flame that flashes up from a cap on the casing and burns more strongly than an ordinary gas jet. The engineer at the pumping station where the well is located stated that enough gas collects in the cap to burn about one-half hour.

The presence, discovered by Mr. Darton several years ago, of an anticlinal arch in Furnas County, has excited much interest in its relation to the possible occurrence of oil or gas, and plans have been made for drilling for these products. The crest of this arch extends down Medicine Creek through Cambridge and southeastward across Furnas County, and if oil or gas are present underground they might be expected along that line. There is, however, no evidence whatever that the region is underlain by rocks containing oil or gas. The Dakota sandstone, which lies about 700 feet below the river at Cambridge has never yielded oil, and probably at a depth of about 1,000 feet it is underlain by red beds, which are nonproductive; the thickness of the latter is unknown, but probably it is over 500 feet. The red beds are underlain by limestone and shale, which might possibly yield some products of value; the depth of these increases rapidly to the west and to the east of the arch.

The Carboniferous rocks which carry oil and gas in southeastern Kansas extend under south-central Nebraska, but several deep wells which have penetrated these rocks in northern Kansas found no oil. The Dakota formation under the Republican Valley carries artesian water under heavy pressure, a condition which would prevent the accumulation of oil or gas. The oil of eastern Colorado is obtained from sandy beds in the Pierre shale, and possibly such beds may be found in the formation in Hitchcock and Dundy counties.

### BUILDING STONE.

Building stone is quarried at many points in the Republican Valley. The Dakota sandstone, though more or less friable and not of pleas-

*A*. NIOBRARA LIMESTONE QUARRY NORTHEAST OF CAMBRIDGE, NEBR.

*B*. TYPICAL SAND HILLS NORTHEAST OF HAIGLER, NEBR.

ing color, is quarried southeast of Endicott and southeast of Kesterson. This material is used mainly for foundations and culverts in Fairbury, Endicott, and Steele. A thin bed of compact sandstone is found in the Dakota formation about 2 miles northwest of Fairbury, which closely resembles quartzite, and a hard sandstone similar in character occurs near Junction, but neither of these is sufficiently extensive to be valuable. The Greenhorn limestone has been quarried for twenty years in the vicinity of Hubbell, and although the present output is only about 40 cars per year it formerly exceeded 200 cars. Most of this stone is now used in the northern part of Kansas. A line of small quarries extends along the hill slopes wherever the Greenhorn formation is exposed. The principal quarries of this rock within this region are located about 5 miles northwest of Fairbury, a few miles northeast of Gladstone, north of Gilead, south of Kesterson, and in the vicinity of Hubbell. Most of the stone is obtained from the so-called Fencepost member, and other beds are worked locally. The product is used principally in building foundations, culverts, and sidewalks. The Greenhorn limestone is used for structural purposes throughout Jefferson, Thayer, and Nuckolls counties. It has been burned successfully to lime northwest of Fairbury.

The Niobrara chalk rock, though soft, has been quarried for building purposes along the Republican, between Superior and Alma. It is easily dressed and its color is not objectionable. The lower member of the formation has been less extensively quarried in Nebraska than in Kansas, where it is crushed at Montrose and used for ballast along the Chicago, Rock Island, and Pacific Railway. At Alma the upper beds of the Niobrara have been used for street pavements. The chalk packs firmly, sheds water, and wears well. In the vicinity of Cambridge, flinty beds of the Niobrara are quarried for building purposes. The A. Brown quarry (Pl. VIII, *A*), 2½ miles northeast of Cambridge, has been worked for twenty years. This flint extends over a wide area in the vicinity of the anticline both in Nebraska and in Kansas, and it might be used as a railroad ballast.

The Tertiary "mortar beds" afford stone suitable for foundation purposes in every county west of Harlan. The so-called "granite" at Woodruff is a compact sandstone, or quartzite occurring in the Tertiary. It is quarried and crushed for railroad ballast and concrete at the Atwood Company's quarry, about 2 miles west of Woodruff, Kans., and about one-fourth mile south of the State line. The stone is very hard, usually olive green in color and fine to medium grained, but the color and texture show some variation. The beds quarried range from 6 to 12 feet in thickness. Stone of this horizon occurs in the vicinity of Lookout Mountain southeast of Franklin, Nebr., where large blocks appear on the slopes of the hill. A ledge of

rock of somewhat similar nature but of finer texture outcrops at places along Republican River in Furnas and Redwillow counties. It is 3 to 4 feet thick, and best exposed south of the river between Bartlett and Indianola.

### CEMENT.

Portland cement is largely manufactured from limestone or chalk mixed with the proper proportion of clay or shale. These materials are ground, thoroughly mixed together and burned, and then reground. The Niobrara chalk rock and the Pierre shale are used in the manufacture of cement at Yankton, S. Dak., and these same formations outcrop along the Republican, where probably they could be utilized for that purpose. Unfortunately, in the area in which the chalk rock is most favorably exposed, it is not overlain by the clay, but large supplies of this ingredient could be obtained at no great distance. Other important factors to be considered in the production of cement, aside from the materials used, are fuel and water supply, but the conditions for these are as favorable in Republican Valley as in some other places where cement is profitably produced.

### CLAY.

The Dakota formation contains extensive beds of high-class clays near Fairbury, Endicott, and Steele. Southeast of Steele the middle member of the formation is composed of light-colored to mottled clays, which appear over an area of several square miles, in slopes rising from the level of the river to an altitude of 1,325 feet. Between Steele and Endicott there is a clay pit from which the product is shipped to Hastings and Beatrice for use in the manufacture of brick and tiling. An abandoned pit near Endicott, which was worked out by a Beatrice firm a few years ago, afforded over 1,000 cars of clay for use in the manufacture of brick, pottery, and tiling. Clays of the Dakota formation produce very fine grades of brick and on that account will doubtless be more extensively used. Unfortunately there are no large towns near the outcrop areas, and the haulage to Lincoln and other principal cities of Nebraska is long and expensive. There are brickyards in most counties of the region manufacturing brick from either Dakota clay, loess, or alluvium. The principal yards are at Fairbury, Hebron, Deshler, Nelson, Alma, Beaver City, and Arapahoe.

### SAND AND GRAVEL.

Some of the deposits of sand and gravel in the Republican Valley will eventually prove to be valuable. The sand is extensively distributed while the gravel is of less common occurrence. Most sandpits are operated for local use, yet a few ship to towns some distance away.

The sands and gravels worked come from the Dakota formation and from Tertiary, glacial, and alluvial deposits, the last two being the most important sources. The Dakota formation contains friable sandstone, which at places afford a small supply of sand. The Tertiary sands are mostly fine grained, but the gravels are locally coarse enough for use as railroad ballast. It is from the stratified deposits formed during the Pleistocene that most of the sand and gravel is obtained. The principal materials are of western origin and outcrop along Little Blue and Republican rivers. Along the former they are intermixed somewhat with materials of glacial origin and are coarser than the deposits farther west. The main center for sand and gravel is Fairbury, but the deposits extend far westward and are worked at or near Superior, Red Cloud, Beaver, Arapahoe, Cambridge, Trenton, and beyond. The sands usually lie in an accessible position just below the loess. There is an inexhaustible supply of coarse sand and fine gravel about Kesterson, Fairbury Junction, Helvey, Powell, and Hebron. The lower surface in Jefferson County is very irregular, resting on the eroded upper surface of older formations. In places the sand is not overlain by loess and at such places very little or no stripping is necessary. Where railroad facilities are favorable the expense of production is low.

The other principal source of sand is the alluvial deposits. The sand in the Republican bottom lands averages too fine for plaster, but might be used as a filler for concrete work and it may yet prove to be adapted to the production of sand-lime brick. Where the deposits along the streams have been derived from near-by glacial sands they have not changed greatly in character, but remain coarse enough for building purposes. This is the case in the deeper parts of the flood plain from Alexandria to Fairbury. The sands along the river at Fairbury are reported more than 80 feet thick at places. In the vicinity of Bostwick a small ravine contains much coarse sand derived from a bed beneath the loess and this sand is used locally for plaster. In many localities there are sand deposits under the loess, but they are not often well exposed.

Sandpits are found in the vicinity of nearly all towns. The largest shipments are from the Chicago, Rock Island and Pacific Railway sandpit, located northwest of Fairbury on a switch of the Nelson Branch. An old pit on a switch of the Chicago, Burlington and Quincy Railroad just west of Kesterson has afforded thousands of tons during the many years in which it has been worked. The St. Joseph and Grand Island Railway ships from a pit about midway between Endicott and Steele.

The sand of the various pits is used principally for plaster, masonry construction, ballast, and in the manufacture of artificial stone. The demand for it is increasing for each purpose named, especially

the last. Artificial stone plants are operating now in most of the larger towns where a supply of sand can be had within a few miles, as at Fairbury, Hebron, Superior, Nelson, Red Cloud, Cambridge, and McCook. The product is becoming not only a rival of natural stone but of brick as well.

### VOLCANIC ASH.

Volcanic ash is a light-colored powdery deposit of volcanic origin. It is thought to have been thrown into the air by volcanoes in the mountains and carried far eastward by the wind, and in some cases to have been again taken up later and redeposited by water. It is composed of hard, angular fragments of volcanic glass resembling pulverized pumice, and occurs as thin beds and irregular pockets in the Tertiary formations. The thickest beds are in Furnas and Harlan counties.

Mr. S. C. Zike formerly hauled and shipped from a pit 5 miles south of Edison from an opening now 30 feet high and over 100 feet long. The ash was shipped to some of the larger eastern cities. Mr. J. C. Gay of Orleans is shipping the ash from that town under the name of silica. The product goes principally to Europe and is used as an abrasive and in the manufacture of sapolio.

The following analysis of Harlan County ash by Mr. R. S. Hiltner gives the chemical composition:

*Analysis of volcanic ash from Harlan County.*

| | Per cent. |
|---|---|
| Silica ($SiO_2$) | 71.56 |
| Iron oxide and alumina ($Fe_2O_3$ and $Al_2O_3$) | 15.04 |
| Calcium oxide (CaO) | 1.19 |
| Magnesium oxide (MgO) | .49 |
| Sodium and potassium oxides ($Na_2O$ and $K_2O$) | 5.51 |
| Sulphuric anhydride ($SO_3$) | .73 |
| Loss on ignition | 5.48 |
| | 100 |

### OCHER.

Two formations carry ocher (hydrated oxide of iron), which is used to a limited extent for paints. The Dakota clays east of Endicott, and in secs. 19, 24, and 30, T. 1, R. 3 E., southeast of Kesterson, contain a large admixture of reddish and yellowish ocher. In the last-named locality the yellowish to reddish deposits extend onto a number of slopes in that vicinity.

Portions of the Niobrara formation are ocherous in much of Franklin and Webster counties, and also on the anticlinal fold farther west, where the Pierre clay has been removed by erosion. At Indianola paints are manufactured from the weathered upper surface of

the Niobrara at a level of 30 feet below the town. The bed is 11 feet thick at a shaft in the western part of the town, and thins out southward. The ocher was mined about twelve years ago; the shaft has been reopened recently by Adolph Smith and J. P. Reiter, who have installed a mill and are now placing several grades of the product on the market.

## WATER RESOURCES.

On account of their economic importance and their close relation to public health the water resources, especially the underground water of this region have been given special consideration. The principal water supplies are obtained from wells, springs, streams, and lakes or ponds. These may be classified as surface and underground waters.

### SURFACE WATERS.

#### GENERAL CHARACTER.

The surface waters in this region are products of local rainfall in a catchment area but very slightly larger than the district to which this report relates. The amount of direct run-off in any region depends on the quantity and nature of the rainfall, the texture of the soil, and the drainage conditions, the maximum amount being where steep slopes prevail and the soil is fine textured. The run-off in this district is largest in the rougher parts of the central counties and eastward, where the rainfall is greater and the fine-grained loess soil covers most of the surface, the minimum amount being lost where the soil is open textured and the land not surface drained. In the sandhill region and in most of the Tertiary area the direct run-off is small and much water is absorbed; the rainfall is light and the soil is very porous.

In certain canyons heading high in the table-lands the run-off is large, especially after a hard, driving rain. Train Canyon, for example, has bare clay slopes, great declivity, no springs, and never carries water except after what is called a waterspout. At such times water fills the canyon and flows out into the Republican Valley with force sufficient to deflect the river temporarily across its flood plain. The railroad bridge across the lower course of the canyon has been damaged by this rush of water.

#### REPUBLICAN RIVER.

Republican River heads in the table-lands of eastern Colorado many miles east of the Rocky Mountains, and, entering Nebraska in the southwestern corner of Dundy County, flows east about 250 miles across that State before it turns south into Kansas, near Superior.

The principal affluents are South Fork, Frenchman River, and Medicine, Sappa, and Prairiedog creeks. In Colorado its valley is mostly in porous Quaternary and Tertiary deposits, but in Nebraska it is excavated in impervious Cretaceous rocks. Throughout its course the river flows over a deposit of alluvium of its own deposition. The depth of the valley bottom below the bordering table-lands and loess plains varies from 200 to about 400 feet.

The stream is mostly shallow and relatively wide and its sandy bed is bordered by low sandy banks, except in places where it cuts into bordering terraces, where the banks are higher and precipitous. The river scours its right bank much more than the left. A typical view of the river is given in Pl. IX, *A*.

Throughout its course the stream is supplied by spring-fed tributaries. In the western counties, where the rainfall is small and direct run-off is rapid, the river bed often is dry in midsummer immediately above the mouths of Buffalo, Rock, and Frenchman creeks, while the flow from these streams revives the flow in the river below their mouths. This loss of water at the surface is due to evaporation, especially where the water is used for irrigation. Such alternating dry and running portions of the course of the river extend as far east as Superior during periods of drought. Only once in twelve years has the river ceased to flow at Red Cloud and Superior. The river water is useful mainly for stock, irrigation, and power. The following data were compiled by Mr. J. C. Stevens, of the United States Geological Survey:

*Estimated monthly discharge of Republican River at Benkelman, Nebr., 1895, 1903, 1904.*

| Month. | Maximum. | Minimum. | Mean. | Total. |
|---|---|---|---|---|
| 1895. | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* | *Acre-feet.* |
| March (30 days) | 162 | 29 | 78 | 4,640 |
| April | 95 | 33 | 59 | 3,520 |
| May | 281 | 0 | 25 | 1,540 |
| June | 830 | 34 | 155 | 9,220 |
| July | 656 | 41 | 120 | 7,380 |
| August | 102 | 0 | 34 | 2,090 |
| 1903. | | | | |
| May (20–31) | 71 | 47 | 58 | 1,380 |
| June | 81 | 43 | 59 | 3,510 |
| July | 112 | 19 | 39 | 2,400 |
| August | 61 | 26 | 32 | 1,970 |
| September | 47 | 19 | 39 | 2,320 |
| October | 54 | 43 | 49 | 3,010 |
| November (1–20) | 64 | 50 | 56 | 2,220 |
| 1904. | | | | |
| March | 111 | 46 | 89 | 5,478 |
| April | 124 | 30 | 65 | 3,870 |
| May | 99 | 23 | 54 | 3,310 |
| June | 227 | 46 | 91 | 5,430 |
| July | 211 | 5 | 40 | 2,520 |
| August | 165 | 10 | 29 | 1,780 |
| September | 46 | 0 | 15 | 892 |
| October | 195 | 30 | 61 | 3,750 |
| November | 87 | 55 | 65 | 3,810 |

*A*. REPUBLICAN RIVER SOUTH OF BOSTWICK, NEBR.

*B*. SAND-HILL LAKE, DUNDY COUNTY, NEBR.

*Estimated monthly discharge of South Fork of Republican River at Benkelman, Nebr., for the years 1903–1905.*

| Month. | Discharge in second-feet. | | | Total. |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| 1903. | | | | *Acre-feet.* |
| May (20–31) | 57 | 36 | 48 | 1,140 |
| June | 65 | 7 | 37 | 2,200 |
| July | 36 | 7 | 15 | 922 |
| August | 79 | 7 | 25 | 1,540 |
| September (1–5 and 14–30) | 22 | 7 | 15 | 655 |
| October | 50 | 22 | 39 | 2,400 |
| November (1–20) | 65 | 50 | 57 | 2,260 |
| 1904. | | | | |
| March | 102 | 31 | 60 | 3,690 |
| April | 66 | 6 | 21 | 1,260 |
| May | 255 | 47 | 92 | 5,680 |
| June | 397 | 47 | 132 | 7,850 |
| July | 115 | 5 | 39 | 2,420 |
| August | 89 | 11 | 24 | 1,480 |
| September | 47 | 5 | 13 | 774 |
| October | 115 | 31 | 57 | 3,540 |
| November | 66 | 47 | 59 | 3,530 |
| 1905. | | | | |
| March (17–31) | 249 | 96 | 159 | 4,730 |
| April | 300 | 52 | 141 | 8,390 |
| May | 137 | 52 | 100 | 6,150 |
| June | 283 | 21 | 68.6 | 4,080 |
| July | 152 | 5 | 35.4 | 2,180 |
| August (1–13) | 96 | 21 | 47.7 | 1,230 |

*Estimated monthly discharge of Republican River at Superior, Nebr., 1897–1903.*

[Drainage area, 22,347 square miles.]

| Month. | Discharge in second-feet. | | | Total in acre-feet. | Run-off. | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | Sec.-ft. per sq. mile. | Depth in inches. |
| 1897. | | | | | | |
| March | 650 | 385 | 510 | 31,360 | 0.023 | 0.026 |
| April | 2,870 | 620 | 1,244 | 74,020 | .056 | .062 |
| May | 1,130 | 180 | 420 | 25,820 | .019 | .022 |
| June | [a] 750 | 180 | 359 | 21,400 | .016 | .018 |
| July | 4,310 | 119 | 922 | 56,690 | .041 | .047 |
| August | 1,460 | 94 | 259 | 15,920 | .012 | .014 |
| September | 241 | 0 | 71 | 4,220 | .003 | .003 |
| 1898. | | | | | | |
| April | [b] 2,130 | 490 | 755 | 44,930 | .03 | .03 |
| May | 1,870 | 500 | 1,053 | 64,750 | .05 | .06 |
| June | 2,300 | 560 | 1,235 | 73,490 | .06 | .07 |
| July | 1,340 | 220 | 479 | 29,450 | .02 | .02 |
| August | 380 | 100 | 195 | 11,990 | .01 | .01 |
| September | 470 | 185 | 289 | 17,200 | .01 | .01 |
| October | 365 | 145 | 264 | 16,230 | .01 | .01 |
| November | [c] 470 | 320 | 382 | 22,730 | .02 | .02 |
| 1899. | | | | | | |
| March | [d] 956 | 60 | 706 | 43,410 | .031 | .015 |
| April | 842 | 375 | 578 | 34,390 | .026 | .029 |
| May | 1,800 | 292 | 511 | 31,420 | .023 | .026 |
| June | 4,040 | 141 | 531 | 31,600 | .021 | .023 |
| July | 1,380 | 209 | 458 | 28,160 | .020 | .023 |
| August | 868 | 136 | 303 | 18,630 | .014 | .016 |
| September | 102 | 6 | 50 | 2,980 | .002 | .002 |
| October | 101 | 24 | 53 | 3,260 | .002 | .002 |
| 1900. | | | | | | |
| April | 1,670 | 565 | 909 | 54,090 | .04 | .04 |
| May | 2,940 | 320 | 735 | 45,190 | .03 | .03 |
| June | 674 | 250 | 392 | 23,330 | .02 | .02 |
| July | 349 | 67 | 159 | 9,780 | .006 | .007 |
| August | 1,280 | 24 | 149 | 9,160 | .006 | .007 |
| September | 2,010 | 8 | 156 | 9,280 | .006 | .007 |
| October | 148 | 26 | 69 | 4,240 | .003 | .003 |
| November | [e] 162 | 36 | 87 | 5,180 | .004 | .004 |

[a] June 1–25.
[b] April 20–30.
[c] November 1–19.
[d] March 19–31.
[e] November 1–24.

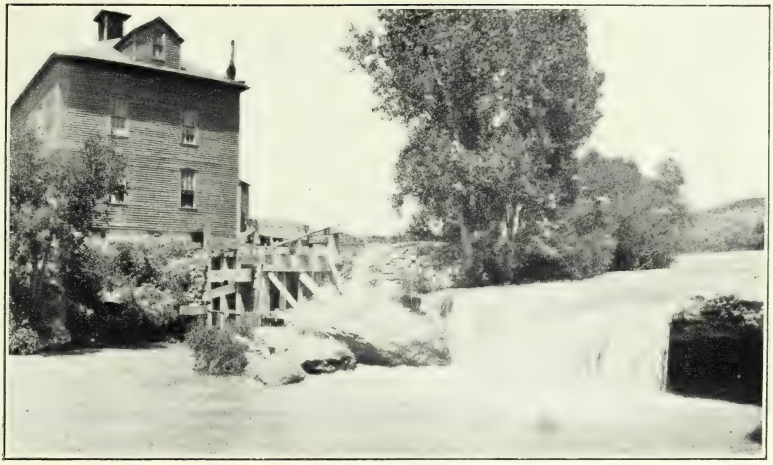
*Estimated monthly discharge of Republican River at Superior, Nebr., 1897–1903*—Cont'd.

| Month. | Discharge in second-feet. | | | Run-off. | | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Total in acre-feet. | Sec.-ft. per sq. mile. | Depth in inches. |
| 1901. | | | | | | |
| April | 1,510 | 637 | 961 | 57,180 | .043 | .048 |
| May | 622 | 146 | 364 | 22,380 | .016 | .018 |
| June | 480 | 117 | 219 | 13,030 | .010 | .011 |
| July | 154 | 5 | 44 | 2,620 | .002 | .002 |
| August | 856 | 5 | 70 | 4,300 | .003 | .003 |
| September | 4,990 | 10 | 1,246 | 74,140 | .056 | .062 |
| October | 1,490 | 285 | 443 | 27,240 | .020 | .020 |
| November | 1,030 | 312 | 419 | 24,930 | .019 | .021 |
| 1902. | | | | | | |
| March | [a] 920 | 330 | 675 | 29,450 | .03 | .02 |
| April | 740 | 390 | 555 | 33,020 | .02 | .02 |
| May | 2,810 | 335 | 1,269 | 78,020 | .06 | .07 |
| June | 3,240 | 320 | 1,372 | 81,640 | .06 | .07 |
| July | 12,490 | 970 | [b] 3,080 | [b] 189,360 | [b] .14 | [b] .16 |
| August | 1,920 | 330 | 674 | 41,440 | .03 | .03 |
| September | 10,880 | 155 | 1,175 | 69,910 | .05 | .06 |
| October | 1,990 | 520 | 937 | 57,610 | .04 | .05 |
| November | 970 | 460 | 622 | 37,010 | .03 | .03 |
| 1903. | | | | | | |
| March | [c] 7,750 | 1,260 | 2,692 | 96,110 | .120 | .080 |
| April | 1,260 | 705 | 918 | 54,620 | .041 | .046 |
| May | 14,100 | 845 | 4,491 | 276,140 | .201 | .232 |
| June | 6,460 | 835 | 1,921 | 114,310 | .086 | .096 |
| July | 7,820 | 465 | 1,948 | 119,780 | .087 | .100 |
| August | 3,280 | 520 | 1,230 | 75,630 | .055 | .063 |
| September | 700 | 270 | 389 | 23,150 | .017 | .019 |
| October | 390 | 245 | 326 | 20,040 | .015 | .017 |
| November | 690 | 130 | 417 | 24,810 | .019 | .021 |

[a] March 9–31. [b] Exclusive of four days' flood discharge. [c] March 14–31.

### FRENCHMAN RIVER.

Frenchman River is fed by several tributaries in Chase, Perkins, and Hayes counties and flows southeastward to join the Republican at Culbertson. Only a small part of its drainage basin is within the region to which this report relates. The upper tributary streams are in deep, steep-walled canyons and gather most of their water from springs issuing from the Tertiary. Farther downstream, where the slopes decrease in grade, the valley widens and is cut in Pierre clay. Near its mouth the stream is shallow and from 75 to 100 feet wide. It flows over a sandy bed in which there are small sand bars and islands. At Wauneta, in Chase County, the river falls about 8 feet over a hard ledge of Tertiary rock, as shown in Pl. X, *A*. A flour mill is run by power from this fall.



*A*. FALLS OF FRENCHMAN RIVER AT WAUNETA, NEBR.

*B*. SPRING IN DUNDY COUNTY, NEBR.

*Estimated monthly discharge of Frenchman River at Palisade, Nebr., for 1895 and 1896.*

| Month. | Maximum. | Minimum. | Mean. | Total. |
|---|---|---|---|---|
| 1895. | *Second-feet.* | *Second-feet.* | *Second-feet.* | *Acre-feet.* |
| March | 118 | 98 | 105 | 6,460 |
| April | 156 | 107 | 137 | 8,150 |
| May | 158 | 111 | 129 | 7,930 |
| June | 600 | 50 | 132 | 7,850 |
| July | 580 | 54 | 158 | 9,720 |
| August | 437 | 64 | 96 | 5,900 |
| September | 98 | 68 | 78 | 4,640 |
| 1896. | | | | |
| May | 200 | 92 | 114 | 7,010 |
| June | 800 | 50 | 104 | 6,190 |
| July | 145 | 80 | 94 | 5,780 |
| August | 92 | 63 | 76 | 4,670 |
| September | 89 | 77 | 82 | 4,880 |
| October | 89 | 76 | 82 | 5,040 |

### REDWILLOW AND MEDICINE CREEKS.

Redwillow and Medicine creeks are similar to each other in origin and flow, and although they have a long course they carry but a small volume of water. They rise in canyons near Platte River, in Lincoln County, and flow to the Republican through deep narrow valleys in a nearly level upland. Each has sufficient power for the successful operation of flour mills.

### BEAVER AND SAPPA CREEKS.

Beaver and Sappa creeks are much alike in flow and drainage area, heading in the vicinity of the Colorado line and receiving the run-off of a considerable portion of northwestern Kansas. They flow northeastward parallel to the Republican, unite in the eastern part of Furnas County, and join the Republican near Orleans. Both creeks flow over a bed of alluvium lying on the Niobrara formation. The volume of water is small, but the flow is constant in the Nebraska part of their courses, where it is augmented by the run-off and by several tributaries fed by small springs. Only one gaging is on record. It was made on Beaver Creek one-fourth of a mile below the mill at Stamford by J. A. Green, July 6, 1904. The surface width below the confluence of the creeks is 21 feet; the area of the cross section of the stream is 33 feet; the mean velocity 95 feet, and the discharge 36 second-feet.

### PRAIRIEDOG CREEK.

Prairiedog Creek rises in Kansas, but flows for a few miles through Harlan County, which it enters with volume about as great as that of Sappa Creek. Near its mouth, south of the town of Republican, the creek cuts into the Niobrara chalk, which causes small rapids in its bed. The stream is not now used in Nebraska either for power or irrigation.

### LITTLE BLUE RIVER.

Little Blue River is next to the Republican in volume. Its tributaries rise in the loess plains, principally in the vicinity of Hastings, and gather water from the long slopes extending to the brink of the Platte Valley. The general slope of the drainage basin is southeastward, and the river flows into Kansas in the southeastern part of Jefferson County. The drainage area comprises approximately 13,000 square miles, in Webster, Nuckolls, Thayer, and Jefferson counties; in this region the flow is constant, even during periods of dry weather. Much of the water is derived from springs issuing from Quaternary sands and from Dakota sandstone. The river rises considerably during freshets, and during these times has a strong tendency to shift its channel in the sandy bottom lands. During the past year the stream has straightened its course at several places, cutting across some valuable farm lands, notably between Endicott and Steele, south of Alexandria, and near the Chicago, Rock Island and Pacific Railway bridge between Hebron and Gilead. These changes in the channel cause much damage to land, crops, and roadways, and they are much more frequent on this stream than on the Republican.

### SPRINGS.

Springs have their source in ground water which issues at the surface under various conditions. The principal horizons at which springs occur in the region are (1) the contact zone between the Tertiary and the underlying Pierre and Niobrara formations, (2) the base of Quaternary materials of western origin where they overlie impervious Cretaceous beds, and (3) the Dakota sandstone, especially when this lies above clay beds.

Many small and a few large springs appear at the first-named horizon, which extends along the entire length of Republican River in Nebraska to its headwaters in Colorado. Most of these springs are located north of the river, the strongest being at or near the heads of tributaries. Among the best examples are those on the Moore ranch northeast of Haigler (Pl. X, *B*), and a spring near Trenton.

In the counties as far west as Hitchcock, and as far east as Franklin, both Tertiary and Quaternary sands yield spring water, but along the tributaries of Little Blue River in northern Thayer and Jefferson counties water comes entirely from the Pleistocene sands. Big Sandy Creek is a good example of a stream which derives its water from these sands.

Spring water from the Dakota sandstones appears to come from two sources. Part of it from distant sources is artesian water escaping along the outcropping area of the formation from eastern Thayer County to the Kansas line. Some of this water flows into the same

streams that receive water from the Quaternary sands. The Dakota sandstone outcrops south of Rose Creek, probably derive their spring water from the local rainfall, the water percolating down to clay beds and then outward to the surface.

### LAKES.

In the undissected loess plains much of the rainfall is caught and retained in the soil and in numerous temporary ponds during wet weather. Some of these ponds are 8 to 10 feet deep after exceptionally heavy rains, and while a few contain water throughout the year most of them either remain marshy or dry up during the summer months. Such ponds occupy only a small part of the surface in the level uplands, and they are most frequent in counties lying just north of the eastern part of the region. Some of the wet-weather lakes have been drained and the land thus reclaimed for agricultural purposes.

In the sand hills, where the drainage channels are poorly defined, the rainfall soaks into the sands and at the time of heavy rains water fills the basins sometimes to a depth of several feet. Humus and fine silt carried into the basins help to check the downward movement of the water, causing it to accumulate at the surface during rainy weather. There are several examples of such lakes in Dundy County, notably between the heads of Buffalo and Rock creeks (Pl. IX, *B*).

Storage of surface water by means of artificial ponds has been practiced to some extent, especially near heads of spring-fed streams. Examples of this kind are found in Rock and Buffalo creeks of Dundy County. There are lakes also at various localities where the water is held by mill dams.

## UNDERGROUND WATERS.

### SOURCE OF GROUND WATERS.

The volume of water absorbed by the ground near the surface varies not only with the amount of precipitation but also somewhat with topographic conditions, which promote or retard surface drainage, and especially with the porosity of the soil. Some of the absorbed water is lost by evaporation and some percolates to lower levels. The loess is porous and the vertical structure of the formation is a favorable feature, but the fine texture of the material greatly diminishes its capacity for absorption. The rate of motion of water downward through the various formations varies with the texture and pressure, the motion being more rapid in coarse sands and gravels than in rocks of finer texture. The Cretaceous clays are of such fine grain that they check the downward motion of the ground water, thus often causing it to accumulate in the more porous overlying sands and

gravels. The thickness of the latter varies from 0 to 100 feet, and the amount of ground water which they hold is very great. The Tertiary and Quaternary sands and gravels, when completely saturated, contain from 25 to 30 per cent or more of water. Owing to underflow, however, the beds are usually not filled to the top but only up to a subsurface plane, which may be level or sloping, known as the "water table."

Water stored underground in this manner is often the accumulation of many years. The amount is increased and the water table raised by an increase in rainfall, and is lowered correspondingly during long periods of drought. This subsurface storage of water is the main supply for springs and wells and is a source of much of the moisture supplied to growing crops.

### QUALITY OF UNDERGROUND WATER.

Underground water contained in the different geologic formations varies much in quality, quantity, and accessibility. Tertiary sands and gravels usually carry an abundance of soft to medium-hard water at moderate depths. The water of the other formations is slightly hard, "alkali" or saline, containing minerals dissolved from the rocks during the slow percolation of the water. Pollution by organic matter is also common, especially in surficial deposits. Most of the Cretaceous formations contain considerable soluble mineral matter, and as a result, their waters often are not of good quality. This is especially the case with the Pierre, Niobrara, Carlile, and Graneros formations, the supply from which is often unfit for domestic purposes. The porous sandstone of the Dakota formation usually yields good water in large supply, but it is hard and often heavily charged with iron. Not a few wells in this formation yield water too saline for drinking and house use. Alkali water is most common in regions where the Pierre shale outcrops or lies close to the surface.

The waters from Tertiary sands have wide distribution and are readily accessible. Often they contain but little mineral matter, although water from the alluvium sometimes contains much alkali, derived from the underlying Pierre shale.

### DEPLETION OF SUPPLY.

The water supply near the surface is subject to considerable variation in amount, for there is constant evaporation and a natural drainage to lower levels.

The amount of underground water lost by seepage or springs is considerable. It would be much greater, however, were it not for the usual presence of a loesslike alluvium along the seepage horizon

in the main valleys, which checks the rapid flow of water to the surface.

Considerable water near the surface also is lost by evaporation, a factor which increases in importance from east to west. From an open water surface the evaporation averages about twice the precipitation in the western counties of Nebraska. Water stored deep in the soil is not subject to much loss by evaporation. Water drawn from wells, though comparatively inconsiderable in relative amount, is a direct drain on the underground supply.

### SHALLOW WELLS.

Water of good quality and in large amounts can be obtained by wells at moderate depths in most of the region treated in this report. The principal sources of supply are the Dakota sandstone, Quaternary sand, gravel, and alluvium, and the Tertiary deposits. Wells are bored, drilled, driven, or dug, and the casings most used are wood, galvanized iron, stone, tile, and gas pipe. In some instances no casing is required.

The shallowest wells are along valleys, and the deepest wells, which vary from 100 to 300 feet in depth, are on the uplands. The local conditions in each county are presented more specifically on later pages in this report.

### WEAK AND DRY WELLS.

The volume of water which may be pumped from a well within a given time depends on several factors, the principal one of which is the rate at which water is delivered to the well from a water-bearing formation. This is controlled more by the size of the spaces between the grains of sediment than by the depth to which a well is sunk below the water table, a fact illustrated by a well at N. J. Allen's ranch, 12 miles northeast of Haigler. At first this well ended above the "magnesia" rock and the water was supplied from fine sand and all the water could be pumped out in thirty minutes. When the pump was stopped the water slowly rose again to the level of the water table. Later the well was deepened to reach a bed of coarse gravel, which yielded water in such volume that apparently it was not weakened by three hours pumping with a gasoline engine having an output of over 15,000 gallons. This type of well is duplicated at many other places on the uplands, for the conditions are similar over a wide area. The well on the ranch of Mr. J. McAlee, on the bottom below Benkelman, is one of the best examples of a strong valley well deriving its water from alluvium. This well is 1 foot in diameter and 27 feet deep, and when pumped at the rate of 150 gallons a minute the water level is lowered only a short distance. It then remains stationary during vigorous pumping and as soon as the

engine is stopped the water rises to its normal level in a few seconds. The source of supply here is in coarse gravel lying on Pierre shale.

In some wells the water is supplied from fine sands, and, although the volume of water may be large, yet its movement to the well is so slow that the yield is small. One of the best ways to obviate this disadvantage is to increase the size of the well, which gives a larger reservoir in which the water may accumulate.

Weak wells also result when the water table is greatly lowered by dry seasons.

In the case of some weak wells the supply can be increased by sinking to greater depth, providing of course the Cretaceous shales or chalk rock are not entered.

In some districts wells fail to obtain any water, but these are almost invariably in localities where the surface of either the Niobrara or the Pierre formation rises above the water table. A narrow zone presenting these conditions borders each side of the Republican Val-

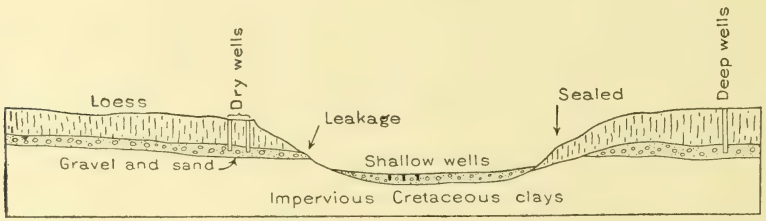



FIG. 2.—Section across a valley in southwestern Nebraska, illustrating the ground-water conditions.

ley throughout its course in Nebraska and extends for some distance up its tributaries. It is due to the fact that the Republican and its tributaries have eroded their valleys from 30 to over 100 feet in depth in the Cretaceous clays, permitting the ground water in the overlying formations to drain out on the slopes. The width of these zones varies considerably and is greatest where the tributary valleys are long and frequent and there are numerous deep ravines. As soon as the well driller strikes Pierre clay or the Niobrara formation he should discontinue the well and move to a point farther from the breaks at the edge of the valley, if an upland well is desired, or to some point on the valley bottom below. The ideal cross section of a valley shown in fig. 2 will serve further to illustrate the conditions described above. The escape of water is checked by loess and terrace materials on the right side of the section shown in this figure.

In T. 7, R. 25, northwest of Cambridge, much trouble has been experienced in obtaining water. A well there, 130 feet deep, reached the Niobrara and found no water, while another well 2 miles farther north tapped the water table and an abundance of ground water at

110 feet. In that region as elsewhere the depth to ground water increases while passing from the edge of the dry-well zone to the higher level upland. There are five dry wells on sec. 36, 12 miles south of Trenton. Near Deer Creek, 7 miles northeast of Cambridge, there are seven such wells on 1 acre of the Sullivan farm, each reaching the Niobrara formations at a depth of over 100 feet. After sinking the holes on the Sullivan farm the driller moved 20 rods northward and obtained plenty of water in a well somewhat shallower.

### BLOWING WELLS.

Blowing wells occur in most counties in southern Nebraska, the largest number being in Jefferson, Thayer, Dundy, and Hitchcock. They are present in the loess area where the water level is some dis-

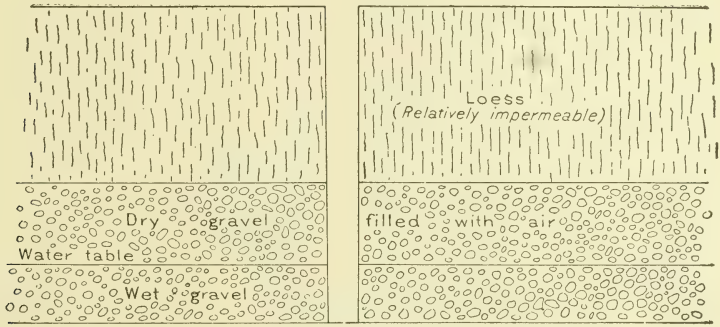



FIG. 3.—Section showing blowing-well conditions.

tance below the top of the underlying gravels, the upper beds of the latter being dry.

The cause of the motion of air in these wells appears to be changes in pressure of the atmosphere with which the periods of inhalation and exhalation closely correlate. Fig. 3 shows the conditions under which "blowing wells" occur.

During the time of high barometer or heavier air pressure air moves down the well into the dry gravel, and when the atmospheric pressure diminishes the air comes out of the well. At times of stationary pressure there is no movement. The well, then, is an artificial opening between the loess-covered gravel, with its spaces filled with air, and the surface, where pressure is frequently changing. The loess is so much less pervious to the air than the gravel is that the movement of air through it is very slow, while the well affords a ready channel for upward or downward movement. The velocity of the movement of course varies with the difference in pressure between air in the gravel and that at the surface, with the porosity of the gravel and of the overlying loess bed, and with the depth and diam-

eter of the well. The strongest blowing is usually in wells of small diameter. Changes in the water level also increase or diminish the thickness of the dry gravel; a rise of the water table to top of the gravel would displace the air.

A well at the ranch of C. E. Weeks, 4 miles northeast of Fairbury, is a good example. It is 118 feet deep and a strong blower.

A well at Harbine, owned by George Wells, will blow the hat off of one's head. Numerous other similar examples occur on the uplands north of Alexandria, Stoddard, Hubbell, Indianola, and Benkelman. The blowing appears to bear little or no relation to the available water supply. During the coldest times of winter much trouble is experienced by the freezing of pipes, due to the inhalation of cold air, and in the well of C. E. Weeks, referred to above, the water pipe sometimes has frozen as far down as 100 feet.

Numerous pumps in the upland wells near Arapahoe have to be pulled during the coldest periods of winter on account of bursted pipes. A safety cock is now placed in most pipes about 30 feet below ground, and in very cold weather it is opened to serve as a drain. By this method and by the use of hot water freezing is often prevented. Blowing wells also are natural barometers and thus indicate approaching changes in the weather.

### POLLUTION OF SHALLOW WELLS.

As well water is supplied from the surface of the ground by percolation it is subject to dangerous contamination from drainage from outhouses, barnyards, and pigpens. No part of the farm home should be guarded with more care than the well, for polluted waters are frequently the source of disease. Wells should be cleaned frequently, and curbing that has begun to give odor and taste to the water should be replaced. Often decaying casing will render good water unfit for use. The well should be so situated that surface drainage will be away from the well and never toward it.

In case there are two or more water-bearing formations from which a supply of water for domestic use may be obtained, the well should be located so as to secure the more suitable water. The problem is not so much the amount as the quality, when the supply is to be used for drinking purposes. It should be better understood that shallow poorly kept wells are a certain source of disease, and that their proper location and care is essential for the health of all those using the water.

Along the chalk bluffs in the Republican Valley there is a tendency to place the well below the house and lots, usually well on the valley bottoms, where there is plenty of water but increased possibilities of pollution. At many such places wells can not be sunk above the house because of the Niobrara or Pierre formations in

the valley slopes, which do not yield good water, but even under this circumstance they can be located out of the line of drainage from the barn and other unclean spots. If placed up-valley from the house, lots, and outhouses the chances of pollution are greatly lessened.

### WINDMILL PUMPING.

Water is raised by windmills at many places in the valleys and on the uplands from wells of various depths. The primitive method of lifting water by bucket and windlass is now rarely seen, having been supplanted by windmills, there being usually enough wind to propel these for at least part of the day.

### IRRIGATION FROM WELLS.

It has been hoped that the wells of the uplands and valley bottoms of the southwestern counties of Nebraska would yield enough water for the irrigation of large areas, but the supply has been found inadequate at most localities. There is, however, sufficient water for use in gardens for raising fruit, vegetables, and flowers, and, to a limited extent, for certain crops. The best known irrigation plant using well water is on the valley bottom a short distance southeast of Benkelman (see Pl. XI, *A*), at the ranch of Mr. J. McAlee, where a 20-acre garden has been irrigated for two years from a single well 27 feet deep. The water is raised by a gasoline engine pumping 150 gallons a minute into a reservoir covering three-fourths of an acre to a maximum depth of 6 feet. During the year 1903, the income from the garden was $960, after losing much by frost.

### ARTESIAN WELLS.

One purpose of this investigation was to ascertain the prospects of securing flowing wells, but the results were not altogether conclusive. The Dakota formation, containing a thick mass of water-bearing sandstones, underlies most of the region described and should be expected to yield artesian flows along at least a part of the Republican Valley. It is overlain by impervious clays and shales in the counties from Thayer westward, and while these beds are not of great thickness apparently, no boring thus far drilled in the Republican Valley has reached the Dakota sandstone. Unsuccessful attempts have been made at or near Arapahoe, Indianola, McCook, and 5 miles east of Haigler. The boring at Arapahoe was discontinued at about 912 feet when the drill must have been very near the Dakota sandstone. A weak flow, which continued for a short time, was found at a depth of about 550 feet. A well at McCook, about 405 feet deep, flowed a few gallons a day. The water in both wells appears to come from the Niobrara formation.

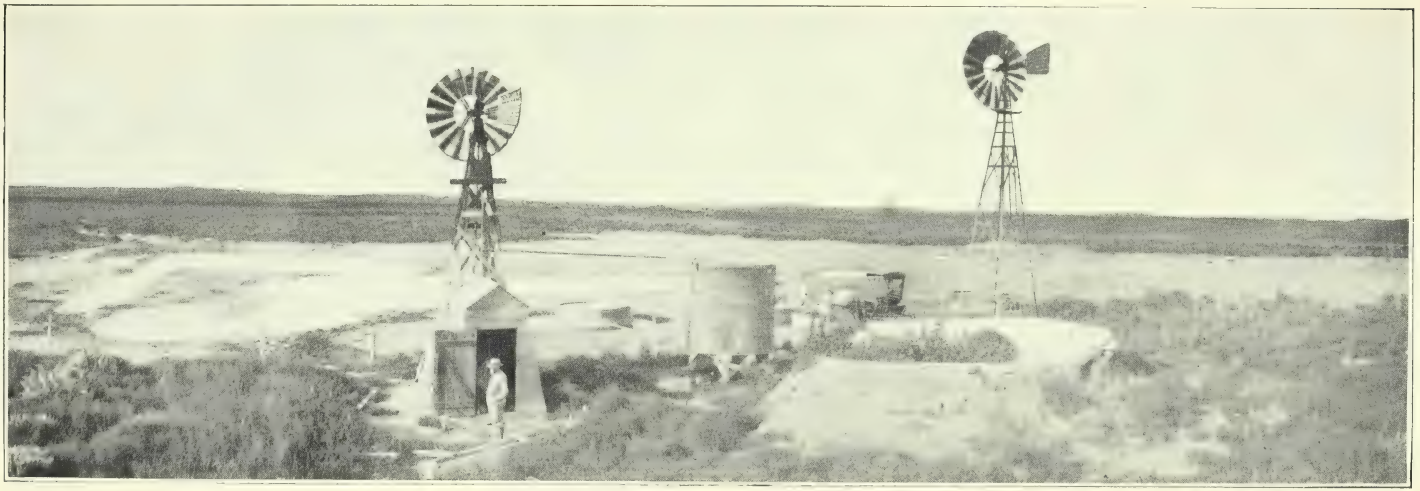
There are several unfavorable conditions for satisfactory flows in southern Nebraska. In the first place the outcrop of the Dakota formation extends across Jefferson County and southwestward across Kansas, and the leakage by springs and seeps is so complete that the artesian pressure is finally all lost. To the west there is a gradual rise of pressure toward the intake zone along the mountains, but the rate is low, perhaps not as much as the general rise at the bottom of the Republican Valley, especially from Furnas County eastward. The margin is small either way, and the true condition can be determined only by a boring in the valley sufficiently deep to penetrate the Dakota formation. A second factor is found in the structure of the Dakota formation: The sandstone or water-bearing beds, where exposed in Jefferson County, appear to be interrupted by clay beds which are usually near the middle of the formation, but which may possibly cut off or displace the sandstones locally. If such a condition exists under the western counties the continuous underground motion of the water might be greatly hampered. In general the beds outcropping appear to show a less favorable structure for an artesian supply under heavy pressure than is found along Missouri River in South Dakota and northeastern Nebraska. Wells reaching the Dakota sandstones in Jefferson and Thayer counties often obtain saline water, which is usually under some pressure, but with one exception, not under enough to lift it to the surface.

The Permian beds have been reached by at least two wells in Jefferson County. In one of them 3 miles south of Fairbury and 336 feet deep, saline water rose 200 feet. Near Steele a weak saline flow was obtained at 195 feet. These examples indicate that there is sufficient pressure in the Permian beds to force water to the level of the bottom lands along the river in the southern part of Jefferson County. The quality, however, is unfavorable for domestic and stock purposes.

A few wells in Tertiary deposits find water under slight pressure. A well of this kind, located on the place of Mr. J. W. Kinsley, 10 miles north and 2 miles east of Benkelman, has the water level so near the surface that it could be piped out.

There is a small area of flowing wells about Alexandria on the valley bottom adjoining Big Sandy Creek. It extends some 4 or 5 miles east and west and about the width of the flood plain north and south. The flow was discovered and developed by Mr. E. N. Averill, who has four or five wells. The first well, which was put down in 1899, did not flow at first, but now there are about twenty flowing wells. They vary from 40 to 60 feet in depth; passing through soil, 2 to 4 feet; sands, with first water, 30 to 35 feet; blue clay, about 5 feet; and peaty clay or old soil to water in coarse alluvial sand or fine gravel. Most of the wells are bored 11 inches in diameter and cased with wood, though in some the casing is galvanized iron. One of the

*A.* McALEE IRRIGATION PLANT AT BENKELMAN, NEBR.



*B.* WINDMILLS IN SAND HILLS OF WESTERN NEBRASKA.

Averill wells, only 2 inches in diameter, flows 50 gallons per minute, has a head of 4 feet, and temperature of 49° F. The water is forced by a ram to a 500-gallon tank 600 feet distant and 24 feet above the well, from which it is piped through Mr. Averill's residence.

The other wells flow into a pond used as a source of ice, for boating, and for fish culture. This pond is 250 by 350 feet across and 5 to 6 feet deep. The first well completed at the pond (see Pl. XII, *A*), flowed 110 gallons per minute.

The source of water appears to be in the Dakota sandstone which immediately underlies the alluvial valley filling. The basin, as has been shown, is small and local, and the pressure is sustained by a clay bed which overlies the water-bearing sand.

## WATER SUPPLY, BY COUNTIES.

### DUNDY COUNTY.

All Dundy County is underlain by the Pierre shale, the surface of which rises 25 or 30 feet above the river at Max and Benkelman and about 100 feet in the vicinity of Buffalo Creek and Haigler. Next above is the Tertiary, which in the northwestern part of the county has been worked over into dune sands and in other sections is overlain by loess. The alluvium along the Republican averages between one-half and three-fourths mile wide, exclusive of the higher terraces.

South of the river the water supply varies considerably as to amount and quality and wells often fail to obtain a sufficient supply, while in the southeast wells ending in the Pierre shale afford bad water. Along the bottom lands water is obtained at depths ranging from 15 to 60 feet, the deeper wells being located on benches. Some of the water varies in quality from hard to alkaline. At Benkelman a good supply of water is reached at depths varying from 20 to 112 feet, the deeper wells being high on the valley slope. The well at Mr. J. M. McAlee's irrigation plant at Benkelman has been described on page 43. An equally strong well, also sunk in the alluvial gravels, affords water for the Burlington and Missouri River Railroad. It is reported to have supplied 50,000 gallons of water in four hours.

Farther up the Republican Valley the best supplies of well water are secured from the alluvium on the north side. At Haigler, located on a bench on the south side, the wells are deeper than usual, being from 45 to 60 feet deep. They afford water of poor quality, owing to the underlying Pierre shale. A town well is used as a public watering place, but the water now used for domestic purposes and drinking is hauled from a shallow well near the river.

In the uplands north of the river the ground-water table varies considerably in depth. In the sand-hill region it is reached by shallow wells varying from 10 to 80 feet in depth, while on the highest part of the divide, between the Frenchman and the Republican, the

depth is from 200 to 308 feet, the amount decreasing to the south and the west. In all this part of the county the water table is not easily lowered by the hardest pumping. The water is usually soft or medium hard. At most places it occurs in two horizons in the Tertiary, one above and the other below a fairly definite zone of "magnesia" rock, parts of which are extremely hard and difficult to dig or drill through. Some wells derive their water from the rock. Most of the recent deeper upland wells are tubular, but during the early occupation of the country dug wells were most common. In one dug well three and one-half days were required for penetrating a hard bed 3 feet thick.

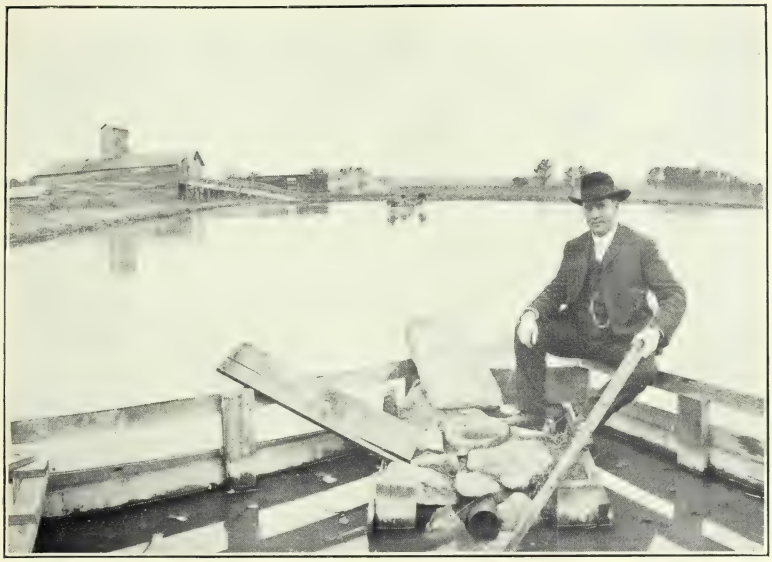
Tributaries of the Republican from the north are fed by some of the strongest springs in Nebraska, but while most of the strong, heavy springs are located in the north-side valleys there are also a few on the south. A notably strong spring occurs on the Drummond place, 6 miles northwest of Haigler, from which the water is piped one-fourth mile to the stock yards and house.

*Representative wells of Dundy County, Nebr.*

| Owner. | Location. | Depth of well. | Depth of water. | Materials penetrated. |
|---|---|---|---|---|
| | | *Feet.* | *Feet.* | |
| McAlee, J. M | Benkelman, on bottom | 27 | 24 | Sand and gravel to Pierre clay; water in gravel. |
| Arla Cattle Co | Parks, on Rock Creek bottom | 28 | 12 | Soil, sand, and gravel. |
| Allen, N. J | Sec. 20, T. 1, R. 40, near bottom | 30 | 10 | Dry sand 12 feet; coarse wet sand to water in gravel. |
| Larned, William | Sec. 33, T. 1, R. 41, near bottom | 40 | 20 | Soil, loam, and sand. |
| Brady, James | Sec. 25, T. 1, R. 42, on bottom | 42 | 8 | Soil, gravel, and Pierre shale. |
| | Sec. 31, T. 2, R. 36, on bottom | 30 | 10 | Soil and sand. |
| Tockler, A. A | Sec. 14, T. 2, R. 38, on upland | 80 | ..... | Soil and sand 27 feet; "magnesia" rock to water. |
| Allen, N. J | Sec. 19, T. 2, R. 40, sand hills | 63 | 30 | Soil, sand, and black loam 27 feet; gravelly sand 2 feet; quicksand 18 feet; "magnesia" rock 7 feet to gravel. |
| Richards, I. B | Sec. 14, T. 3, R. 36, highland | 209 | 3½ | Loess 100 feet; soft sand rock 8 feet; sand 5 feet; clay 20 feet; rock 58 feet; clay, rock, sand, and gravel to water. |
| Lewis, F. B | Sec. 1, T. 3, R. 37, low slope | 48 | 13 | |
| Larison, F. M | Sec. 8, T. 4, R. 37, highland | 225 | ..... | |
| Johnson, M. M | Sec. 29, T. 4, R. 36, highland | 245 | 15 | Soil, loess, and "magnesia" rock. |
| Nesmith, M. W | Sec. 17, T. 4, R. 36, highland | 238 | ..... | Soil, loess, sand, and "magnesia" rock to water. |
| Ough, William | Sec. 17, T. 4, R. 37, highland | 200 | 14 | Black soil 5 feet; clay 140 feet; sand 12 feet; "magnesia" 30 feet; rock 5 feet; gravel 8 feet. |
| Krausmick, E | Sec. 24, T. 4, R. 37, highland | 262 | 15 | Soil, loess, and "magnesia" rock. |

### HITCHCOCK COUNTY.

The principal streams in Hitchcock County are Republican and Frenchman rivers and Driftwood Creek, the valley slopes of which are formed by Pierre clay, Tertiary deposits, and loess. Frenchman River is a valuable source of irrigation water, while the Republican varies greatly in volume.



*A*. ARTESIAN WELL AND RESERVOIR AT ALEXANDRIA, NEBR.

*B*. DAM IN REPUBLICAN RIVER AT SUPERIOR, NEBR.

Springs are numerous, and they supply much water for domestic purposes and stock. Most of them are located north of the Republican and issue at scattered localities from the Pierre-Tertiary contact. The explanation of their irregular distribution is the varying height to which the impervious shales and clays rise above the river, and the presence in places of a covering of either loess or alluvium, which often prevents the surface escape of water. In the vicinity of Trenton the Pierre-Tertiary contact extends along the valley slopes at or near the surface at a level about 20 feet above the bottom land, and springs often appear along it. A few miles east and west the water horizon is more deeply covered on the slopes, and springs cease. About midway between Trenton and Culbertson the Tertiary contact extends down nearly to the level of the river, and the spring horizon is lowered correspondingly. Springs south of the river lie principally on the north branch of the Driftwood, only one of good size being found on the south branch.

Most of the uplands are covered by loess underlain by Tertiary water-bearing sands and gravels with occasional beds of the so-called "magnesia" rock. Impervious Pierre shale underlies all of the county below the Tertiary and prevents water from sinking below the base of the Tertiary deposits.

Bottom lands along the Republican in Hitchcock are broader than in Dundy County. Those of the Frenchman vary from ½ to 1 mile in width. It is stated that the average depth of wells in the bottom lands in the county is from 25 to 35 feet. An abundance of good cool water is usually obtained in coarse alluvial sand or gravel just above the Pierre shale, and while wells often reach this shale, they do not penetrate it. The water table in the alluvial beds rises and falls with the river near the channel, but the influence is local. The quality of the water at places along the outer edge of the flood plain near the Pierre shale slopes is often unsatisfactory. This condition is found at Stratton, where the supply varies from good to bad from wells averaging 30 feet deep. Most wells in Trenton are driven. Several years ago a well was sunk near the depot of the Burlington and Missouri River Railroad in that town to a depth of 300 feet. No accurate record was kept, but doubtless the drill penetrated the Pierre shale and may have extended a short distance into the Niobrara formation.

Wells on the upland in this county resemble those in the eastern part of Dundy County. On the higher lands near the Frenchman they are often deeper, one being 347 feet. It passed through soil, loess, and Tertiary rock, sand, and clay, to water-bearing gravel. The depths on the uplands between the Republican and the Frenchman vary from 100 to over 300 feet, and the first water is always found below thick beds of "magnesia" rock, and usually above a bed

of clay. The second water lies in coarse sands and gravel. Blowing wells are not uncommon where there is a bed of dry gravel above the water-bearing horizon. Water in the deep wells on the upland is said to be warmer and softer than that obtained along the Republican bottom. It is claimed that there is a notable difference between the waters of the upland wells and those in Trenton.

The deepest wells on the uplands in the southern part of the county are 220 to 240 feet, and in some of them 85 feet of "magnesia" rock have been encountered above water. On the school section, 12 miles south of Trenton, 5 dry wells were put down, all ending in Pierre shale.

*Representative wells of Hitchcock County, Nebr.*

| Owner. | Location. | Depth of well. | Depth of water. | Materials penetrated. |
|---|---|---|---|---|
| | | *Feet.* | *Feet.* | |
| Powers, J. H | Sec. 16, T. 1, R. 32, upland | 96 | 12 | Soil, 2 feet; loess, 1 foot; silt to within 1 foot of water-bearing sand, and gravel at bottom. |
| Brumley, M. M | Sec. —, T. 2, R. 35, upland | 90 | 8 | No record. |
| Frey, J. W | Sec. 14, T. 2, R. 33, upland | 127 | 10 | Do. |
| Small, John | Sec. 3, T. 2, R. 33, bottom | 13 | 6 | Do. |
| Miller, C. J | Sec. 5, T. 3, R. 33, upland | 196 | 12 | Black loam, 50 feet; soft rock, 80 feet; dry sand, 2 feet; sand 64 feet; water in sand above rock. |
| Morgan, T. D | Sec. 34, T. 3, R. 33, upland | 100 | 7 | Black soil, 4 feet; loess, 86 feet; sand and gravel, 16 feet |
| Powers, C. R | Sec. 35, T. 3, R. 33, upland | 108 | | Black soil, 3 feet; loess, 70 feet; sand, 30 feet; gravel, 5 feet. |
| Williams, J. M | Sec. 12, T. 4, R. 32, lowland | 42 | | Soil, clay, and sand to water. |

## REDWILLOW COUNTY.

The streams of most importance in Redwillow County are Republican River and Redwillow, Driftwood, and Beaver creeks. They flow in rather wide bottom lands from 200 to 400 feet below the highest uplands. The underlying formations are the same as those found in the next county west, except that near the eastern border the Pierre thins out and the Niobrara gradually rises so that it attains an elevation of 100 feet above the river near Cambridge.

Wells on the bottom land range from 20 to 50 feet in depth. At McCook large amounts of water are drawn from this source for railroad and city use, six large wells having been dug on the first bottom to a depth of 26 feet to the top of the Pierre shale. At Indianola the water lies from 12 to 20 feet below the surface, but most wells are driven to gravel at a depth of 45 or 50 feet. A few wells near the valley slopes in the northern part of the town reach ocherous Niobrara beds and yield a poorer quality of water. On the broad bottom lands near the mouth of Redwillow Creek water lies within a few feet of

the surface, and at the Redwillow store a well is driven 20 feet in the soil and sand. In the uplands south of Indianola the water is in Tertiary rock and gravel, and is reached by wells from 100 to 260 feet in depth, most of them being 140 to 160 feet deep.

It is reported that there are good water supplies in the uplands south of Indianola in the region where the formations dip westward. Farther southeast, in the area of ocher and flint, dry wells are common. In the highlands north of Indianola wells range from 150 to 300 feet in depth, and northwest of Cambridge from 100 to 125 feet.

The water table in the uplands in this county lies approximately level, a feature due to the configuration of the surface of the underlying impervious beds, which rise 100 feet above the river near Cambridge and only a few feet above at McCook.

Springs, though found at a number of places in the county, are not as large nor as numerous as in adjoining counties.

A deep boring at McCook has been reported as having penetrated 405 feet [a] of the Pierre shale, but for most of the distance it was in Niobrara formation, of which it did not reach the bottom. The flow is weak and unfit for use.

*Representative wells of Redwillow County, Nebr.*

| Owner. | Location. | Depth of well. | Depth of water. | Materials penetrated. |
|---|---|---|---|---|
| | | *Feet.* | *Feet.* | |
| Schippe, G. P. | Lebanon, 7 miles E. of, lowland. | 48 | 6 | Bench and clay. |
| Bennett, Donald | Lebanon, 5 miles E. of, lowland. | 40 | ..... | Bench and clay; loess. |
| Brandt, Fred | Wilsonville, 6 miles W. of, upland. | 160 | 3 | Loess, rock, clay, sand; small supply. |
| Brockman, Frank | Wilsonville, 5 miles W. of, upland. | 120 | 3 | Loess, clay. |
| McMurrin, D. H. | Sec. 20, T. 1, R. 30, upland | 170 | 7 | Loess and magnesia rock. |
| Anderson, Andrew | Sec. 11, T. 1, R. 30, upland | 27 | 5 | Loess and rock. |
| Caldwell, L. C. | Sec. 10, T. 1, R. 30, upland | 155 | 4 | Sand, loess, magnesia rock. |
| Benjamine, W. A. | Sec. 23, T. 1, R. 30, upland | 229 | 8 | Soil, loess, rock, sand, clay, gravel. |
| Moore, Frank | Sec. 24, T. 2, R. 26, upland | 150 | ..... | Soil, soft sandstone, 24 feet; coarse gravel, 4 feet; small supply. |
| Reper, Geo. P. | Sec. 3, T. 2, R. 29, on slope | 70 | ..... | Soil, gravel, sand. |
| Rodgers, F. E. | T. 2, R. 29, 3 miles SW. of McCook. | 75 | 10 | Loess, sand. |
| Lincoln Land Co. | Sec. 29, T. 3, R. 29, McCook | 405 | 407 | Sand, and Pierre and Niobrara formations; small flow. |
| Boyce, N. | Boxelder post-office, 2 miles E. of, upland. | 162 | 10 | Soil, 2 feet; loess, 60 feet; Tertiary rock, 80 feet; Tertiary rock and sand, 18 feet; Pierre 2 feet. |
| Sharp, William | T. 4, R. 30, 7 miles NW. of McCook, upland. | 240 | 4 | Loess, rock, gravel. |

[a] Another deep boring in progress in 1905, with a depth of over 700 feet, was not deep enough to reach the base of the Graneros formation. Some sandstone, penetrated at a depth of about 700 feet, appears to belong to a bed which usually occurs near the top of the Carlile formation.—N. H. D.

### FURNAS COUNTY.

The principal streams in Furnas County are Republican River and Medicine, Beaver, and Sappa creeks. Only a small portion of the course of Medicine Creek lies in the county.

Springs are found in several localities, but are not an important source of supply. Those used most are south of the river between Arapahoe and Edison, northeast of Beaver, and about midway between Cambridge and Holbrook. Seepage springs are common along Sappa Creek near the Nebraska-Kansas line and in the small creeks near Arapahoe.

Well water obtained on bottom lands along the valleys is usually good, but at places it contains alkali, especially in shallow wells on the first bottom. Most wells at Cambridge are on the bottom lands and on an average are driven 35 feet to second water; the first water, somewhat alkaline, is reached at 10 to 15 feet. In Holbrook, Arapahoe, Edison, and Oxford similar conditions prevail, except that in Arapahoe the second water is found only in a few localities and dry wells are more frequent. These dry wells are due to the Pierre shale rising so high as to cut off the ground water.

At certain points, as at the park well, the alluvium deepens locally. The park well is 8 feet in diameter and 44 feet deep; below its bottom four 3-inch sand points extend to a total depth of 48 feet.

In Wilsonville, Hendley, and Beaver the water supply is derived from alluvial sands and gravel lying immediately above Cretaceous shale. At Wilsonville first-water wells are about 20 feet deep. The second water lies in sand under clay about 18 feet below the first water, and is reached by wells 35 to 40 feet in depth. At Hendley second water is obtained in wells 40 feet deep. Conditions along the Beaver and Sappa bottoms are similar to those at Wilsonville and Hendley, but there are dry wells at places.

Wells on the uplands between the Republican and Beaver vary in depth from 100 to 260 feet, with an average of about 150 feet. They pass through much Tertiary rock. On the ranch of William Dickerson, between Beaver and Arapahoe, 100 feet of rock were encountered. In the well on the ranch of William Rone, 6 miles south and 2 miles east of Arapahoe, the water rises considerably. In a well 7 miles north of Beaver the water rises nearly to the surface, and might be drained out, giving a continuous flow.

On the slopes near the valley bottoms much trouble has been experienced with dry wells, but this feature is less frequent north of the Republican than south. The best known dry-well areas are located east of Hendley, northeast of Beaver, and on the slope south of the Republican, the last named extending nearly across the county. The wells in most cases end in the Pierre shale, at an elevation of

from 20 to 40 feet above the level of the river. In the southwestern part of the county they end in the Niobrara at still higher levels.

On the upland north of the river the water table is from 100 to 140 feet below ground, varying with the distance from the valley. The second water lies in gravel about 40 feet below the first, the two being separated by rock. Some wells, extending only to first water, dry up during times of drought.

Tubular wells are losing favor in Furnas County. The points clog up by the deposition of mineral matter within a few years, and as a result they have to be pulled and cleaned in order to obtain a necessary supply of water.

Prof. A. d'Allemand, of Arapahoe, furnished the writer with a log of the 912-foot boring drilled in 1894 at that town, but it is difficult to make out a very accurate section from the log. It was discontinued on account of a disconnected drill which was not removed from the hole. The drilling ended in the Graneros shale, apparently near the Dakota.

*Representative wells of Furnas County, Nebr.*

| Owner. | Location. | Depth of well. | Depth of water. | Materials penetrated. |
|---|---|---|---|---|
| | | *Feet.* | *Feet.* | |
| Young, L. W. | Sec. 3, T. 1, R. 25 | 85 | ..... | Sand and sand rock alternating. |
| Anderson, R. A. | Sec. 21, T. 1, R. 25, upland | 190 | ..... | No record. |
| Landgrun, John | Sec. 9, T. 1, R. 24, upland | 180 | ..... | Loess, sand, Tertiary rock. |
| Burns, G. C. | Sec. 25, T. 2, R. 25, bottom | 38 | 12 | Terrace-alluvium and gravel |
| Johnston, Sam | Sec. 31, T. 2, R. 25, bottom | 40 | 8 | Do. |
| McComb, J. P. | Sec. 31, T. 2, R. 25, bottom | 40 | 10 | Do. |
| Hanug, L. P. | Sec. 22, T. 2, R. 24, upland | 109 | 10 | Loess, clay, sand; small supply. |
| Do | Sec. 23, T. 2, R. 24, upland | 85 | 10 | Do. |
| Pierce, C. H. | Sec. 27, T. 2, R. 24 | 40 | 15 | Loess, clay, Niobrara. |
| Snodderly, Henry | Sec. 30, T. 2, R. 24 | 30 | 3 | Tertiary rock to gravel and water. |
| Larson, Victor | Four miles NW. of Hendley | 186 | 5 | Loess, sand, Tertiary rock and shale; small supply. |
| Powell Bros. | 1½ miles E. of Hendley | 200 | None. | Loess, shale. |
| Daniels, M. | Sec. 25, T. 3, R. 21, upland | 186 | 6 | Loess, sand. |
| Zehe, Peter | Sec. 24, T. 4, R. 23 | 35 | 7 | No record. |
| D'Allemand, A. | Arapahoe | 36 | 8 | Loess-like clay, clay, gravel. |
| Vanralin, I. J. | Sec. 18, T. 4, R. 23 | 35 | ..... | Soil, sand. |
| Daniels, S. W. | Sec. 19, T. 4, R. 20, lowland | 78 | 60 | Soil, clay, sand, gravel. |
| Trammel, J. W. | Oxford | 65 | 18 | Soil, loess, sand, and water, rock, gravel. |

HARLAN COUNTY.

Pierre shale underlies most of Harlan County, but the Niobrara chalk rock is exposed along lower levels of the principal valleys.

A sufficient supply of good water is obtained in most parts of the county, yet dry wells are not uncommon in or near towns along the Republican and at places on the uplands near Prairiedog Creek. Wells on the first bottom of the Republican range from 12 to 30 feet in depth. Those on the terrace in the lower part of Alma vary from 45 to 50 feet; in the north part of that town they are about 70 or 80

feet, while at a higher level on the slope the depths are somewhat less, a condition hardly to be expected. The water table lies at about the same depth under the benches and first bottom at Alma, Orleans, and Republican, and the wells at each place are similar, except that more difficulty has been experienced with dry wells at Orleans than at the other towns named. At Stamford it has been found difficult to obtain good water. The town is located on a high bench in which the Pierre shale rises above the water table.

On the uplands between the Republican and the Prairiedog valleys, the water is contained in Tertiary sands and gravels beneath a bed of rock; the wells range from 100 to 150 feet in depth, the deepest one, 170 feet, being an exception.

At a few miles distant from the river on the high land north, water is usually obtained from Tertiary gravels lying beneath rock. Farther away from the river it is reached in sands lying above the rock. The deepest wells are in the vicinity of Ragan, one being 260 feet.

Wells in the northeastern part of the county, where the shallow lakes occur, vary from 140 to about 200 feet in depth.

Important springs are found along the Prairiedog, northeast of Alma, and at several other localities.

*Representative wells of Harlan County, Nebr.*

| Owner. | Location. | Depth of well. | Depth of water. | Materials penetrated. |
|---|---|---|---|---|
| | | *Feet.* | *Feet.* | |
| Moore, W. R. | Sec. 4, T. 1, R. 19, upland. | 70 | 6 | Sand-lime rock and clay 20 feet; then rock and sand to water. |
| Gillispie, D. O. | Sec. 3, T. 1, R. 17, on slope. | 54 | ..... | Soil, sand, clay, sand. |
| Haskins, M. H. | Sec. 15, T. 1, R. 17, bottom. | 27 | ..... | Soil, clay, sand. |
| Cook, J. M. | Sec. 15, T. 2, R. 20. | 71 | ..... | No rock. |
| Smith, James. | Sec. 15, T. 2, R. 17, upland. | 100 | 5 | No record. |
| Klein, C. F. | Sec. 4, T. 2, R. 20, upland. | 122 | 8 | Do. |
| Popert, M. | Sec. 3, T. 2, R. 20, bottom. | 40 | ..... | Soil, clay. |
| Do. | Sec. 4, T. 2, R. 20, upland. | 117 | ..... | No record. |
| Giles, E. W. | Sec. 7, T. 3, R. 20, bottom. | 70 | 46 | Loess and sand; stopped on rock. |
| Peck, George. | Sec. 19, T. 1, R. 17, upland. | 90 | 10 | Loess 50 feet; sand 40 feet. |
| Hutchinson, M. I. | Sec. 35, T. 4, R. 20. | 50 | ..... | Soil, clay, sand, gravel. |
| Uebel, G. W. | Sec. 20, T. 4, R. 20, upland. | 215 | 70 | Soil, loess, Tertiary rock, sand and gravel to Pierre shale. |
| Pettygrove, N. A. | Sec. 17, T. 4, R. 20, upland. | 140 | 20 | Soil, loess, sand, gravel. |
| Bayley, Mrs. D. | Sec. 21, T. 4, R. 20, upland. | 228 | 83 | Soil, loess and Tertiary rock, sand, and gravel on Pierre shale. |

## FRANKLIN COUNTY.

The underlying impervious beds in Franklin County are the Niobrara chalk rock, which underlies the entire area, and the Pierre shale, which is limited to the western part. The first-named formation rises east of Naponee, carrying the water table high above the river,

The water-bearing beds are the same in this county as in Harlan, but a larger amount of well water is derived from the upland sands and gravels. The locality in which it is most difficult to secure an adequate supply of good water is south of the river, where the wells are usually dry or contain water of poor quality. Their depths average about 100 feet near the State line.

On the lowest bottom lands the water is at a depth of 10 to 20 feet. At Naponee plenty of water is obtained from wells 30 to 40 feet deep. About Bloomington and Riverton there are many unsuccessful wells. A well at the foot of the slope at Bloomington is 46 feet deep, ending in gravel. Another, three-fourths mile north, on the slope is 60 feet deep, supplying good water. At Franklin water is obtained in coarse sand lying above the Niobrara chalk rock.

In the uplands north of the river the water table varies from 100 to about 200 feet in depth, the amount increasing with the altitude. At Moline the average depth to water is about 160 feet, and in the vicinity of Upland it is about 150 feet. In a well at the ranch of James Grant, 2 miles south of Macon, accounted one of the best on the first ridge, the water level is 142 feet below ground. In the vicinity of Campbell the depth to the water table ranges from 150 to 190 feet, and wells vary in depth from 170 to about 200 feet, being shallower along the depressions.

This county has many small springs which feed the creeks north of the river. A good example is the W. E. Ewing spring, three-fourths mile northeast of Franklin. It is used for dairy, house, and stock purposes, and eventually may be piped to Franklin for town use. The fall from the spring to the main part of the town is between 60 and 70 feet.

*Representative wells of Franklin County, Nebr.*

| Owner. | Location. | Depth of well. | Depth of water. | Materials penetrated. |
|---|---|---|---|---|
| | | *Feet.* | *Feet.* | |
| Miller, W. A | Sec. 11, T. 1, R. 15 | 20 | 3 | Soil, sand, and gravel to Niobrara chalk. |
| Hoffhenhe, George | Sec. 2, T. 2, R. 14, upland | 130 | 5 or 6 | No record. |
| Davis, Will | Sec. 11, T. 2, R. 14, upland | 132 | 6 | Do. |
| McGinley, H | Sec. 13, T. 2, R. 14, upland | 135 | 6 | Do. |
| Baker, D. W | Sec. 2, T. 2, R. 14, upland | 154 | 5 | Do. |
| Bauerle, G | Sec. 21, T. 2, R. 16, upland | 120 | 15 | Sandy loam and clay; sand at bottom. |
| James, J. H | Sec. 33, T. 3, R. 13, lowland | 36 | 20 | Coarse gravel. |
| Postmaster (Macon, Nebr.). | Sec. 27, T. 3, R. 15 | 170 | ..... | Soil, 125 feet; sand, 50 feet. |
| Byerly, Levy | Sec. 29, T. 3, R. 15 | 185 | ..... | Clay, 120 feet; sand, 65 feet. |
| Zulauf, Chas | Sec. 20, T. 3, R. 17, highland | 230 | ..... | Black soil and sand. |
| Dunn, John | Sec. 20, T. 3, R. 16, highland | 220 | 15 | No record. |
| Amman, Paul | Sec. 17, T. 3, R. 16, highland | 231 | 15 | Do. |
| Hansen, J. Martin | Sec. 28, T. 4, R. 14 | 170 | 15 | Black soil, clay, sand, and gravel. |
| Lorain, H. B | Sec. 20, T. 4, R. 14, highland | 151 | 12 | Sand and clay. |
| Hansen, Nelson | Sec. 16, T. 4, R. 14 | 187 | ..... | Clay and sand to water-bearing gravel. |

## WEBSTER COUNTY.

The underground water conditions in Webster County resemble those described as existing in the eastern part of Franklin County, but the wells average somewhat shallower. Most wells south of the river are in the bottom lands of small ravines, where the chalk rock affords a limited supply of water of inferior quality.

In the uplands north of the river water is obtained from sands and gravel lying between the loess and the chalk rock. It is soft to medium hard, and of good quality. The depths vary from 60 to 100 feet, the deepest wells being in the northwestern part of the county. About Blue Hill and Rosemont the depth to water averages less than 100 feet.

Taken as a whole, the county is supplied with an abundance of good water. Dry wells are found south of the river and at a few places near it on the north. At the ranch of John Griffith, 2 miles west of Red Cloud, a well was driven 225 feet, passing through soil, sand, and the Niobrara chalk rock to the Carlile shale, but it yielded no water. A well in the northern part of Red Cloud extends through loess, sands, and the Niobrara formation to the Carlile shale. The depth is 265 feet, and the water unfit for use.

Inavale, Red Cloud, Amboy, and Guide Rock derive their water supply from alluvial sands and gravel at depths ranging from 20 to 50 feet.

Springs feed most small creeks north of the river. One of the strongest south of the river is about 5 miles from the bridge at Red Cloud.

*Representative wells of Webster County, Nebr.*

| Owner. | Location. | Depth of well. | Depth of water. | Materials penetrated. |
|---|---|---|---|---|
| | | *Feet.* | *Feet.* | |
| Wild, George | Sec. 32, T. 1, R. 12, ravine | 36 | 10 | No record. |
| Noble, N. S. | Sec. 30, T. 1, R. 12, ravine | 30 | 6 | Soil, clay, sand. |
| Sutton, Oliver | Sec. 21, T. 1, R. 12, ravine | 30 | 10 | Do. |
| Dickerson, F. A | Sec. 5, T. 1, R. 9, slope | 60 | 10 | Soil, clay, sand, gravel. |
| Crabill, William | Sec. 7, T. 2, R. 11, slope | 88 | 10 | Loess, gravel, sand. |
| Bondren, Pierre | Sec. 10, T. 3, R. 12, upland | 190 | 6 | Soil, 3 feet; loess, sand. |
| Bean, Emory | Sec. 22, T. 3, R. 12, upland | 140 | 5 | Soil, 3 feet; loess, 90 feet; coarse sand, quicksand, pebbles, gravel. |
| Guerens, Louis | Sec. 5, T. 3, R. 12, upland | 180 | 4 | Soil, loess, gravel, sand, small pieces of rock. |
| Erickson, Mary | Sec. 20, T. 3, R. 11, upland | 130 | 4 | Loess, gravel with occasional pieces of rock, and sand. |
| Snee, Mary | Sec. 35, T. 4, R. 12, upland | 160 | 6 | No record. |
| Hall, Mrs. H. W | Sec. 14, T. 4, R. 11, upland | 95 | 12 | Soil, loess, sand, blue clay, sand. |
| Mattock, J. A | Sec. 3, T. 4, R. 11, upland | 100 | 25 | Soil, loess, broken pieces of magnesia, blue clay, sand. |
| Turner, Mrs. S. F | Sec. 2, T. 4, R. 11, upland | 150 | 30 | Loess, sand, blue clay, gravel, blue clay, sand. |
| James, J. A | Sec. 12, T. 4, R. 10, slope | 82 | 8 | Loess to sand and water. |
| Buschow, F. C | Sec. 10, T. 4, R. 10, slope | 76 | 5 | Loess to sand. |
| Blue Hill | Sec. 9, T. 4, R. 10 | 200 | 70 | Loess, sand, and gravel. |
| Buschow, A | Sec. 4, T. 4, R. 10, upland | 160 | 12 | Do. |
| Choats, C | Sec. 17, T. 4, R. 9, upland | 85 | 18 | Loess, sand. |
| Nelson, Peter | Sec. 16, T. 4, R. 9 | 58 | 27 | Loess. |
| Buzzard, S. H | Sec. 8, T. 4, R. 9 | 50 | 30 | Do. |

### NUCKOLLS COUNTY.

In the uplands of Nuckolls County well water is obtained from sand, often quite fine, lying on the Niobrara formation and Carlile shale at depths ranging from about 60 to 110 feet. In places near valleys where the bed rock is exposed or only thinly covered by sand and soil considerable difficulty has been experienced in obtaining water in sufficient amounts and of a suitable quality. Wells south of the river are much like those similarly located in Webster County. At Nelson certain chalk ridges and dry sand basins have been the cause of unsuccessful wells, while in other locations, in some cases not far away, good wells have been secured.

Towns on benches along the Republican derive a suitable water supply from alluvial sands and gravels.

There are several strong springs in this county, both north and south of the river. The most notable is about 8 miles northwest of Superior. It supplies water for 500 to 1,500 head of cattle.

*Representative wells of Nuckolls County, Nebr.*

| Owner. | Location. | Depth of well. | Depth of water. | Materials penetrated. |
|---|---|---|---|---|
| | | *Feet.* | *Feet.* | |
| Henderson, C. H | Sec. 23, T. 1, R. 8 | 35 | ..... | No record. |
| Reid, Thomas | Sec. 24, T. 1, R. 7 | 40 | 11 | Soil, loess. |
| Howsick, E. W | Sec. 23, T. 1, R. 7 | 51 | 1 | Loess, 30 feet; black clay, 10 feet; sand with water at 46 feet. |
| Spahn, Geo. S | Sec. 14, T. 1, R. 7 | 30 | 5 | Loess, shale. |
| Spahn, Geo. S | Sec. 4, T. 1, R. 7 | 70 | 17 | Loess, sand, chalk rock. |
| Henderson, A. J | Sec. 22, T. 1, R. 6 | 30 | 3 | No record. |
| Whiting, Mabel | Sec. 26, T. 1, R. 6 | 48 | 3 | Water in. |
| Churchill, C. E | Sec. 21, T. 1, R. 5 | 104 | 8 | Soil, loess, sand. |
| Kruse, John | Sec. 23, T. 2, R. 8 | 75 | 8 | Sand and gravel. |
| Coleman, James | Sec. 27, T. 2, R. 8 | 40 | 15 | Do. |
| Yohe, D. M | Sec. 22, T. 2, R. 8 | 36 | 5 | Sand to water. |
| Middletown, Wm | Sec. 15, T. 2, R. 8 | 65 | 20 | Loess, sand, Niobrara chalk. |
| Stien, C. N | Sec. 14, T. 2, R. 8 | 72 | 9 | Loess, sand, gravel. |
| Elledge, Chas | Sec. 13, T. 2, R. 8 | 72 | 4 | Loess, sand. |
| Bishop, C. A | Sec. 9, T. 2, R. 8 | 75 | 4 | No record. |
| Shaw, William | Sec. 3, T. 2, R. 8 | 70 | 4 | Some rock. |
| Baker, W. A | Nelson | 90 | 20 | Dark loam, fine sand, clayey to bottom. |
| Kimmerer, Ira | Sec. 24, T. 2, R. 6 | 48 | ..... | Loess, sand. |
| Ruskin | Sec. 15, T. 2, R. 5 | 120 | 10 | No record; town pump. |
| Smith, J. C | Sec. 26, T. 3, R. 8 | 40 | 20 | Black loam, loess, chalk rock. |
| Beachey heirs | Sec. 34, T. 3, R. 8 | 70 | 3 | Soil, loess, sand, rock, gravel. |
| Brockman, M | Sec. 11, T. 3, R. 8 | 90 | ..... | No record. |
| Nesbit, J. B | Sec. 14, T. 3, R. 7 | 28 | 8 | Do. |
| Wehrman, F. A | Sec. 17, T. 3, R. 7 | 80 | 15 | Loam, loess, sand, shale. |
| Montgomery, D. W | Sec. 8, T. 3, R. 5 | 35 | 6 | Soil, sand. |
| King, William | Sec. 30, T. 4, R. 8 | 90 | 12 | Loess, sand, gravel. |
| Shell, J. F | Sec. 8, T. 4, R. 8 | 50 | 9 | No record. |

### THAYER COUNTY.

The water supply of the upland wells of Thayer County comes from sands and gravels lying on the Carlile and Greenhorn formations, the depth ranging from 70 to 150 feet. At a few places the sands and gravels are dry, as at Byron, where much trouble has been experienced in securing good water for the town. This condi-

tion probably is due to the fact that the Carlile shale rises and displaces the water-bearing beds. Fortunately the Dakota sandstone lies only about 300 feet below the surface at Byron, and its water is of good quality in that part of the county. Wells recently sunk to this source afford an abundance of water, and under pressure sufficient to raise it more than 50 feet.

The Dakota formation underlies all the western part of the county at a depth of from 300 to 350 feet, and appears to contain less salt than farther east. Along the Little Blue Valley and at places near Rose Creek the water obtained from wells in this formation is somewhat salty, and although in some cases it is not too much so for use, in others it is decidedly objectionable.

The Carlile and Graneros shales outcropping along the Little Blue River and Rose Creek valleys contain but small amounts of bad water, unfit for domestic purposes. The Greenhorn limestone affords water of fair quality to a few wells.

Alluvial sands and gravels are the source of most water supplied to towns located on bottom lands. At Hebron wells averaging from 30 to 40 feet deep extend through alluvium to limestone. The small artesian basin at Alexandria has been described on page 44.

Wells at Hubbell vary in depth from 30 to 40 feet, and their supply diminishes somewhat in dry weather.

*Representative wells of Thayer County, Nebr.*

| Owner. | Location. | Depth of well. | Depth of water. | Materials penetrated. |
|---|---|---|---|---|
| | | *Feet.* | *Feet.* | |
| Webber, Fred | Sec. 36, T. 1, R. 4 | 315 | 100 | Loess, sand, 50 feet; shale, 160 feet; limestone, 9 feet; shale to 315 feet. |
| Gaston, Nelson | Sec. 31, T. 1, R. 3 | 88 | 8 | Loess, 20 feet; sand, 68 feet. |
| Forsdick, Stephen | Sec. 35, T. 1, R. 3 | 150 | ..... | No record. |
| Baldwin, D. J | Sec. 9, T. 1, R. 2 | 125 | 5 or 6 | Loess, 80 feet; sand and gravel, 45 feet. |
| Burdick, A | Sec. 31, T. 1, R. 1 | 725 | ..... | No record. |
| Aufderheide, J. H | Sec. 13, T. 2, R. 4 | 98 | ..... | Water in coarse sand 3 feet thick. |
| Werner, Phil | Sec. 11, T. 2, R. 4 | 106 | ..... | No record. |
| Thiernan, H. B | Sec. 5, T. 2, R. 4 | 105 | ..... | Do. |
| Cornell, E. M | Sec. 6, T. 2, R. 2 | 20 | 5 | Do. |
| Dufur, William | Sec. 1, T. 2, R. 2 W | 27 | 10 | Soil, sand, and gravel; at base of limestone bluff. |
| Wheeler, Jennie E | Sec. 4, T. 2, R. 1 W | 71 | 36 | Soil, shale, slate, flint. |
| Houser, Joseph | Sec. 2, T. 2, R. 1 W | 100 | 18 | Soil and sand, 10 feet; lime rock, 13 feet; blue shale with occasional hard beds, 75 feet; sandstone, 2 feet; poor supply. |
| Thiernan, W | Sec. 25, T. 3, R. 4 | 36 | ..... | Soil and loess, 20 feet; sand, 4 feet; coarse sand and gravel 12 feet. |
| Meyer, John | Sec. 21, T. 3, R. 4 | 120 | ..... | Loess, sand. |
| Elting, Charles | Sec. 18, T. 3, R. 3 | 147 | ..... | No record. |
| Scharatt, H. J | Sec. 8, T. 3, R. 3 | 112 | ..... | Do. |
| Upton, R. B | Sec. 4, T. 3, R. 3 | 92 | ..... | Do. |
| Schainost, Fred | Sec. 36, T. 3, R. 1 W | 55 | 22 | Sand, shale. |
| Hergott, Joseph | Sec. 25, T. 3, R. 1 W | 32 | 2 | Soil, 2 feet; clay, 8 feet; limestone and beds of clay, 22 feet. |
| Knape, O | Sec. 36, T. 3, R. 1 W | 173 | 40 | Soil, limestone, shale, sandstone. |

*Representative wells of Thayer County, Nebr.*—Continued.

| Owner. | Location. | Depth of well. | Depth of water. | Materials penetrated. |
|---|---|---|---|---|
| | | *Feet.* | *Feet.* | |
| Hergott, Joseph | Sec. 35, T. 3, R. 1 W | 150 | 18 | Soil and clay, 5 feet; limestone with clay beds, 25 feet; shale to water in sandstone. |
| Bulin, A | Sec. 12, T. 3, R. 1 W | 192 | 16 | Soil and loess, 70 feet; limestone and clay to water in sandstone. |
| Dill, M. C | Sec. 7, T. 3, R. 2 | 70 | 7 | Soil, 2 feet; loess, 61 feet; coarse sand and gravel, 7 feet. |
| Mahoffy, S. A | Sec. 14, T. 4, R. 4 | 80 | ..... | Loess, 30 feet; sand, 50 feet. |
| Wright, G. N | Sec. 36, T. 4, R. 4 | 94 | ..... | No record. |
| Bice, A. W | Sec. 24, T. 4, R. 3 | 84 | 8 | Do. |
| Bushnell, Scott | Sec. 22, T. 4, R. 2 | 90 | ..... | Loess, 40 feet; sand, 50 feet. |
| Thompson, George | Sec. 11, T. 4, R. 2 | 85 | ..... | Soil and gumbo, 2 feet; loess, 18 feet; sand and clay, 65 feet. |

### JEFFERSON COUNTY.

The occurrence of underground water in Jefferson County is very irregular. In localities where the Graneros and Carlile shales are not overlain by water-bearing sand or gravel, the only alternative is to drill or bore into the Dakota sandstone, which supplies water in abundance, indeed, but varying in quality with the locality. In localities where the Graneros shale extends high up the valley slopes, good wells are rare, unless they extend through the shale into the Dakota sandstone. Some of the wells in this sandstone yield good water, but in many of them it is saline, examples of the latter being found at Gladstone and at a number of points between Powell and Steele.

In much of the county a thick deposit of Quaternary sands and gravels beneath the loess affords an abundance of water at depths varying from 70 to 160 feet. These sands and gravels are extensively developed in the uplands east of Fairbury, about Jansen, and north of the Big Sandy.

At Powell the first water in the alluvium lies within a few feet of the surface. At Fairbury, on the bottom lands, where Pleistocene and alluvial sands blend so that it is difficult to distinguish between them, they carry a large supply of water, reached by wells varying from 30 to over 100 feet in depth, the deeper wells being on the valley slope. At Endicott and Steele the supply comes from the Dakota sandstone and alluvium. About Jansen wells usually derive their water from Quaternary sands, but the deepest one extends a short distance into Dakota sandstone.

Numerous springs, some of considerable size, occur among the deep ravines along Rose Creek and other tributaries of Little Blue River. A hotel in Steele is supplied by spring water. A general seepage into Big Sandy and Little Blue River from the Dakota formation and Pleistocene sands occurs in the northwestern part of the county.

*Representative wells of Jefferson County, Nebr.*

| Owner. | Location. | Depth of well. | Depth of water. | Materials penetrated. |
|---|---|---|---|---|
| | | *Feet.* | *Feet.* | |
| Wimer, Eli | Sec. 31, T 1, R. 1 E | 15 | 7 | Soil, clay, limestone, clay. |
| Lobaugh, J. M | Sec. 32, T 1, R. 1 E | ..... | ..... | Rock, clay, soapstone. |
| Simmons, James | Sec. 28, T. 1, R. 1 E | 30 | 20 | No record. |
| Shepherd, Alex | Sec. 16, T. 1, R. 3 | 68 | 9 | Soil, sand, gravel. |
| Boggs, J. O | Sec. 3, T. 1, R. 3 | 81 | 45 | Soil, 4 feet; loess, 10 feet; Dakota clay, 66 feet; sand, 1 foot. |
| Connell, John | Sec. 19, T. 2, R. 1 E | 281 | ..... | Soil and clay, 35 feet; sand, 65 feet; slate, soapstone, and a little coal. |
| Carmony, F. A | Sec. 14, T. 2, R. 2 W | 90 | 6 | Loess, 2 feet; sand, 16 feet; clay, 3 feet; sand, 19 feet. |
| Bodarge, William | Sec. 21, T. 2, R. 2 | 135 | 30 | Soil, 20 feet; lime rock, 30 feet; shale, 60 feet; soapstone, 20 feet; on sandstone with water. |
| Wells, Ed | Sec. —, T. 2, R. 3 | 310 | 175 | Loess and soil, 60 feet; sand and gravel, 70 feet; clay, 180 feet; gravel and sand; water. |
| Spicer, J. R | Sec. 10, T. 2, R. 4 | 40 | 18 | Loess and sand. |
| Landkamer, Geo | Sec. 21, T. 3, R. 1 | 18 | 7 | Hard pan. |
| Weise, John | Sec. 4, T. 2, R. 4 | 125 | 20 | Loess, except 5 feet; black clay and 3 feet glacial sand. |
| Akin, A. M | Sec. 32, T. 3, R. 1 | 100 | 16 | Loam and limestone, 20 feet; slate, 64 feet; sand and sandstone, 16 feet. |
| Schroeder, J. H | Sec. 30, T. 3 N., R. 1 E | 150 | 50 | Soil, 15 feet; slate, 35 feet; limestone; water in quicksand. |
| Moles, D. P | Sec. 26, T. 3, R. 2 | 110 | 40 | No record. |
| Pickens, Wes | Sec. 35, T. 3, R. 2 | 148 | 70 | Do. |
| Janert, William | Sec. 35, T. 3, R. 2 | 227 | 70 | Do. |
| In town (Jansen, Nebr.). | Sec. 34, T. 3, R. 3 | 160 | ..... | Soil, 4 feet; loess, 100 feet; glacial sand, 56 feet. |
| Wrighley, Jas | Sec. 10, T. 3, R. 4 | 115 | 20 | Quicksand. |
| Public well (Harbine, Nebr.). | Sec. 28, T. 3, R. 4 | 122 | 4 | Loam, except 3 feet of sand at bottom. |
| Woodman, Art | Sec. 30, T. 4 N., R. 1 E | 62 | 4 | Loess, 2 feet; sand, 14 feet; clay, 8 feet; sand. |
| Frost, Eph. (owner, Newell, H. J.). | Sec. 27, T. 4 N., R. 1 E | ..... | 9 | No record. |
| Hellwig, Frank | Sec. 26, T. 4 N., R. 1 E | 96 | ..... | Do. |
| Glenn, Mary | Sec. 23, T. 4, R. 1 | 60 | 30 | Loam and sand, 40 feet; slate, 2 feet; sand, 13 feet; lime rock, 1 foot; sand, 4 feet. |
| Wolfe, Cyrus | Sec. 32, T. 4, R. 4 | 130 | 6 | Soil, 8 feet; loess, 80 feet; glacial drift, 42 feet. |

## WATER POWER.

### GENERAL STATEMENT.

Only a brief statement as to the location and maintenance of water-power sites can be given in this report. The water-power prospects in the Republican Valley region are more important than is generally supposed, the plants now in operation employing only a portion of the total power available. The power is now used principally by flour and grist mills and to some extent for electric-light plants. Climatic conditions are an important factor in the industry, for the winters are so open as to permit the use of power during the coldest months. In the western counties there are many sites with limited power along small spring-fed streams, but farther east, where the run-off is greater and streams are supplied liberally from underground sources, greater and more lasting powers are found.

As yet the demand for power is not great. Much grain is now shipped outside the region which might be milled in the valley were it not for the lower shipping rates for wheat than for flour. As a result of this condition the product of most mills is only for local use and but little power is required to grind it. With increasing population, however, and the usual high price of fuel there will be an increasing need for water power.

The power sites are in the basins of Republican and Little Blue rivers and the more favorable locations are on the strongest tributaries. On these the fall or grade per mile is somewhat greater than on the rivers and short dams impound enough water for the mill pond at small expense. Along the rivers dams need to be longer, and consequently are more expensive to construct and to maintain. Republican River usually dries up in the western counties during a part of the summer, a condition which prevents successful development of water power there. Farther east the constant flow affords ample supply, but occasional high waters are apt to cut a new channel to one side of the dam or to do it much damage. This is especially true where the dam lies on sandy alluvium.

### POWER SITES IN THE REPUBLICAN VALLEY.

Several years ago water powers were in operation on Republican River at Oxford, Alma, Franklin, and Red Cloud. Periods of drought and high water brought about their disuse, except at Red Cloud, where the mill was burned. Three powers are now operated along the Republican, near Arapahoe, at Orleans, and at Superior. The dam at Superior is shown in Pl. XII, *B*.

Powers might be obtained at reasonable cost at several places on tributaries of the Republican. The flow of Buffalo Creek in Dundy County varies but little during the year and continues all winter. The stream gages about 10 second-feet with a fall of about 15 feet per mile. Power for use about the house has been employed by Mr. N. J. Allen, who diverts a part of the flow in his irrigation ditch over a small wheel which can be connected to either a churn, washing machine, or grindstone. Aside from this the power of Buffalo Creek is not utilized, and at present there is little demand for it. Rock Creek is nearly as strong as Buffalo Creek and could be made to yield small powers.

Several small powers are available on Frenchman River. Those at Wauneta and Palisade, both outside the area treated in this report, are of most value, the former utilizing a natural fall of 7 feet and an artificial fall of over 1 foot. Redwillow Creek has a dam and mill.

A successful power, located on Medicine Creek, at Cambridge, runs

a mill all the year and practically night and day. A site now not in use is on Big Muddy Creek, northwest of Arapahoe. There are 3 dams in the Sappa-Beaver Creek basin—at Stamford, Beaver, and Wilsonville. A mill formerly operated in the Sappa was moved to Superior, where it is now running. Small spring-fed streams afford sufficient water for small powers at Naponee, Bloomington, and Franklin.

#### POWER SITES IN THE LITTLE BLUE RIVER BASIN.

There are 8 dams now in the Little Blue basin, while another, formerly located near the abandoned town of Meridian, was destroyed by high water.

Most dams in the basin have been damaged by high waters and on that account their maintenance is expensive. The most trouble has been experienced at Hebron and Fairbury. At the former place the river is held in position at heavy expense, because the stream has a strong tendency to cut across the bottom just east of the dam and mill. At Fairbury most of the old dam has been replaced recently by a concrete dam, which it is thought will better cope with high waters. If a dam on the Little Blue is made too high the flow of the stream is diverted over the low banks and the sandy flood plain at times of high water, threatening not only the abutment of the dam but other property as well. Dam sites now in use in this basin are at or near Steele, Fairbury, Alexandria, Hebron, Deweese, Oak, and Blue Bluffs.

#### IRRIGATION.

The principal irrigation now in operation in the Republican Valley region is on the valleys and bench lands, though in some cases the ditches extend out on the lower adjacent valley slopes. The extent of irrigable land is moderately large, but the supply of water is not adequate for reclamation of the entire area. In the eastern and central counties the average rainfall is sufficient for the growth of crops without irrigation, except in an occasional season. At a number of places in the Republican Valley region ditches have been constructed for use during drought, but have been allowed to get out of order during rainy seasons. Furthermore, the principal supplies are at the headwaters of streams, and loss of water by evaporation and seepage during transmission into the broader valleys is great.

It has been found that irrigation along the main valley of the Republican in the western counties is practicable only near the headwaters and below the mouths of some of the strong tributary streams. The best results in that region are obtained between Haigler, Nebr., and Laird, Colo. (see Pl. XIII, *A*), about Benkelman, and along the Frenchman, near Culbertson.

*A*. IRRIGATED ALFALFA FIELD NORTHWEST OF HAIGLER, NEBR.

*B*. BUR-OAK GROVE NEAR ENDICOTT, NEBR.

According to the State engineer about 35,000 acres are under irrigation in the region described in this report. The total length of ditches is about 130 miles, of which apparently less than one-half was operated in 1904. The number of acres irrigated by counties decreases from west to east. The counties including most of the area are Dundy, 17,415 acres; Hitchcock, 13,070; Redwillow, 3,935. In 1904 the area was much less.

## AGRICULTURAL RESOURCES.

### GENERAL STATEMENT.

The utilization of the part of the Great Plains where there is but little rainfall has been a subject of much study. Different methods have been employed from time to time, but they have failed to bring the results which their promoters had hoped to attain. At times stock raising has been thought to be the only industry adapted to the sand hills and dry uplands, while again it has been thought that grain crops might be grown over a large portion of the area. The successes and failures in the unfavored sections have been varied. Settlement has increased and decreased in periods corresponding with the amount of rainfall.

The early attempts at forestation by planting "tree claims" gave poor results, probably because the planting was done crudely and groves were not properly cared for. Very few of the thousands of groves thus started have survived, but a few successful ones show that, if carried on with greater care and with species suited to the climate, good results may be attained.

The introduction of drought-resisting and early-maturing crops is thought by some to be an important factor in reclamation. The crops thus far grown are the forage crops and varieties of oats and wheat.

Dry-farming methods adapted to the rainfall are being promoted at a number of places. The aim is to hold as much of the water in the soil as is possible by proper tillage. The main enemy to soil storage of water is evaporation, and by maintaining a mulch the loss in that manner is reduced to a minimum. To what extent this method, commonly called the Campbell system, will aid in reclamation is not fully proved. It is promoted by the Chicago, Burlington and Quincy Railroad, apparently with good results, and promises to become valuable.

### SOILS.

Agriculture is by far the most important resource of the region, but its results are greatly affected by the local variations in climate, ground water, and soils. The rainfall and ground-water conditions have been described above, but the many different kinds of soils have

not been differentiated. In general, the distribution of the different types corresponds with that of the geologic formations, but minor variations exist, often of considerable importance in plant growth. There are in the region three fairly distinct agricultural provinces—the loess table-lands, the alluvial bottom lands, and the sand hills.

The loess plains of the wide table-lands between the valleys occupy the greater part of the area treated in this report. Where the streams have cut through the loess, the various underlying formations appear with soils of different kinds extending in narrow belts along the valley slopes. Glacial soils, which occur mostly in Jefferson County, are clayey or sandy, with an admixture of pebbles and bowlders. Soils on or below outcrops of Dakota sandstone are sandy, but in places are clayey or ocherous. Extensive alluvial soils occur along the rivers and their tributaries. They contain a high per cent of silt or sand and usually a small proportion of clay. Soils formed from the Cretaceous shales and chalk rock extend along some of the valley slopes not covered by loess or alluvium, and are usually of bad quality for agriculture.

In the sand-hill region loose sandy soil of the dunes consists mainly of quartz sand with but little clay, while in the basins and dry valleys there is an admixture of some humus and considerable clay.

The table-land soil is sandy, and may grade into sand hills on one side and into the so-called plains marl or western loess on the other. The talus slopes below ledges of Tertiary rock are mostly sandy or gravelly.

## CROPS.

### NATIVE GRASSES AND THEIR UTILIZATION.

The region contains a large number of grasses, the distribution of which is controlled by topographic and hydrographic conditions. The highest and heaviest growth is found on bottom lands and eastward over the valley slopes. The drier uplands are quite thickly matted with "short grass." In the sand-hill region the grass covering mostly is thin, except in the dry basins and valleys. In this region there is often much sagebrush and other herbaceous plants, having but little grazing value. In all the counties the meadow grasses are cut for hay, with a total product estimated at 100,000 tons per year.

Three species of blue-stem grasses are of frequent occurrence: *Andropogan furcatus* is abundant on the bottom lands eastward; *Andropogan scoparius* (bunch grass) is widely distributed, extending over bottom lands, onto ridges, and throughout the sand hills; *Andropogan halli* is found on sand dunes and ridges.

Under the name buffalo grass a number of species are usually included. One of these, *Bulbulis dactyloides*, is widely spread over

the dry uplands, and extends as patches in dry basins and valleys in the sand hills. It is very nutritious, and when not too much leached by fall rains serves as one of the best winter foods. The grammas are generally known as buffalo grass, with which they correspond somewhat in distribution and values for grazing. One of them, *Bouteloua oligostachya*, is perhaps the most important dry upland grass. A larger species is more often cut for hay.

The uplands are occupied nearly exclusively at places by wheat grasses, which are not so desirable as the buffalo and grammas. *Stipa conata* is a common species.

### CULTIVATED FORAGE CROPS.

Among the cultivated forage crops alfalfa is first in importance. It is most successfully and extensively grown throughout the region on low bench lands, where it has become an important resource. Three or four crops are cut each year, and are used extensively as swine pasture and for hay. Some of the largest fields are near Indianola, Beaver, and Republican. In the counties farthest west irrigation is employed where water is accessible; a typical irrigated field is shown in Pl. XIII, A. On the uplands about two cuttings are harvested each year. In the sand hills the crop is now grown at a few places where ground water rises close to the surface.

Timothy and clover are not very extensively grown. The principal forage crops raised during drought times and on the driest lands are sorghum, cane, millet, and hungarian. These require more labor in cultivation than alfalfa, and hence are less popular crops.

The following table, showing the acreage of cultivated forage crops, is compiled from the Nebraska Labor Bureau Report for 1903:

*Area of cultivated forage crops.*

[Acres.]

| County. | Alfalfa. | Millet and hungarian. | Sorghum and cane. |
|---|---|---|---|
| Dundy | 618 | 2,021 | 5,403 |
| Hitchcock | 533 | 402 | 10,188 |
| Redwillow | 6,956 | 3,617 | 8,416 |
| Furnas | 10,359 | 2,540 | 10,785 |
| Harlan | 11,683 | 1,959 | 2,262 |
| Franklin | 5,882 | 1,229 | 2,433 |
| Webster | 10,168 | 2,217 | 4,396 |
| Nuckolls | 8,178 | 2,544 | 2,525 |
| Thayer | 4,366 | 1,451 | 2,271 |
| Jefferson | 2,979 | 3,706 | 2,405 |
| Total | 61,742 | 21,686 | 51,084 |

### GRAIN CROPS.

The principal grains cultivated are corn, wheat, oats, and rye. Barley is raised to some extent west of Franklin County. Winter wheat is much more common than spring wheat, especially in the

eastern part of the region. The accompanying table, which is based on the labor bureau report, shows the number of bushels of the principal cereals produced in each county in 1903:

*Quantity of cereals produced in 1903.*

[Bushels.]

| County. | Corn. | Wheat. | Oats. | Rye. |
|---|---|---|---|---|
| Dundy | 806,067 | 40,970 | 6,559 | 13,955 |
| Hitchcock | 668,640 | 446,855 | 5,778 | 172,603 |
| Redwillow | 1,561,681 | 1,555,870 | 24,412 | 459,253 |
| Furnas | 1,986,544 | 1,690,314 | 76,434 | 323,125 |
| Harlan | 1,966,456 | 1,300,690 | 195,397 | 256,481 |
| Franklin | 1,961,008 | 1,066,530 | 401,131 | 48,875 |
| Webster | 2,272,956 | 1,032,475 | 452,231 | 54,725 |
| Nuckolls | 2,977,652 | 923,450 | 485,619 | 72,484 |
| Thayer | 3,212,131 | 1,018,094 | 1,025,303 | 58,119 |
| Jefferson | 2,748,461 | 727,240 | 4,073,478 | 16,350 |
| Total | 20,161,596 | 9,802,488 | 6,746,342 | 1,475,968 |

## FRUIT RAISING.

Numerous wild fruits grow along ravines and in canyons. Cultivated fruits—such as peaches, plums, and cherries—are marketed from a number of large orchards. The W. T. Collins orchards, located on bench lands 1 mile west of Beaver, contain 1,300 peach trees, which were heavily loaded in 1904.

On the place of James Drummond, 6 miles northwest of Haigler and three-fourths mile from the Colorado line, is a successful orchard and vineyard under irrigation. When visited, cherry trees had averaged between 3 and 4 bushels of fruit each, and the apple trees were in promising condition. Mr. N. J. Allen has raised fine peaches and plums by irrigation on a sand-hill point 4 miles east of Haigler. These are but types of a large number of orchards that might be named.

## SUGAR BEETS.

Beets are successfully grown under irrigation on the bench lands of the western counties, but the best crops are raised in the Frenchman Valley above Culbertson and at a number of points along the Republican. The following table shows the acreage of beets by counties and the extent of the crop for 1904:

*Acreage planted in beets, 1904, in southern Nebraska.*

| County. | Acres. | County. | Acres. |
|---|---|---|---|
| Dundy | 92 | Webster | 32 |
| Hitchcock | 686 | Nuckolls | 1 |
| Redwillow | 690 | Thayer | 4 |
| Furnas | 96 | | |
| Harlan | 32 | Total | 1,671 |
| Franklin | 38 | | |

## STOCK RAISING AND DAIRYING.

Stock raising and dairying are closely related to the grass growth, forage, and grain crops already described. The largest stock ranches are located in the thin and short grass regions where most of the land is cheap, and, owing to its subhumid condition, is better adapted to grazing than to other agricultural purposes. The grasses cure on the sod during the time of diminished rainfall in the late summer and fall months and afford pasturage all winter except at times of deepest snowfall. Thousands of cattle and horses "rustle" during the winter without other food. Some winters this lack of care for stock has resulted in heavy losses, especially in former years when most cattle were not provided for; during heavy snowstorms large numbers died more from hunger than from cold. Of recent years winter feed usually is provided for stock during times of exceptionally severe weather and the percentage of loss is greatly diminished.

The western part of the region to which this report relates lies in that part of the Great Plains which is generally known as the "cattle country," yet the number of animals per square mile in the western counties is less than it is farther east where more corn is grown. The day of the open range has passed; now large areas are fenced, in the grazing counties, and controlled by ranchmen.

In the counties farthest east stock are pastured on the roughest land during the grazing months and fed on rough feed in winter. Swine are raised cheaply and in large numbers where alfalfa is most extensively grown.

Dairying has become one of the important industries throughout the region and is successful during both drought and humid years. The cream is shipped from numerous stations to large creameries.

The accompanying table shows the number and distribution of the principal farm animals for 1904:

*Number and distribution of farm animals for 1904.*

| County. | Cattle. | Hogs. | Horses and mules. |
|---|---|---|---|
| Dundy | 15,677 | 5,002 | 2,708 |
| Hitchcock | 13,995 | 4,254 | 3,549 |
| Redwillow | 17,663 | 16,566 | 4,501 |
| Furnas | 33,238 | 29,688 | 11,307 |
| Harlan | 26,402 | 21,888 | 8,546 |
| Franklin | 24,926 | 25,876 | 7,732 |
| Webster | 33,690 | 34,690 | 10,089 |
| Nuckolls | 22,000 | 26,939 | 6,865 |
| Thayer | 29,202 | 26,586 | 11,487 |
| Jefferson | 26,054 | 27,218 | 8,303 |
| Total | 242,947 | 218,707 | 75,087 |

### TIMBER.

Early settlers and prairie fires destroyed much of the natural tree growth, which appears to have been more prevalent at the time of the country's first occupation than it is now. However, the traveler while passing along the open valleys is apt to underestimate the amount of timber growing in the region as, for the most part, it is confined to ravines and the rough lands adjacent to the larger valleys.

Cottonwoods are found both in groves and isolated on all valley bottoms. Along the Frenchman Valley and in the canyons of northeastern Dundy County there are cottonwood trees 2 to 3 feet in diameter, and one located 7 miles northwest of Fairbury is over 6 feet in diameter. Willows, represented by one or more species, are found in all valleys of any considerable size.

Bur oaks follow up and cover the sandy slopes in Jefferson County, and occur westward along the Little Blue and in the lower course of the Republican Valley (see Pl. XIII, *B*). Elms are found in largest numbers on the bottom lands in Jefferson, Thayer, and Nuckolls counties, but extend westward on the alluvium to Dundy County. Parts of Sappa Valley were formerly covered with large elms. Walnut trees of large size grow in the valley bottoms as far west as Red Cloud. A tree nearly 3 feet in diameter is reported south of Naponee.

Ash and boxelders are scattered among other species in the valley portions of the region. Straggling cedars remain on the bluffs of Webster, Franklin, and Nuckolls counties, and a small pine is reported as having been found in a ravine south of Bloomington. The tree growth is utilized for firewood, posts, and lumber.

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WS 216. Geology and water resources of the Republican River Valley and adjacent areas, Nebraska, by G. E. Condra. 1907. 71 pp., 13 pls.

The following papers also relate to this subject: Underground waters of Arkansas Valley in eastern Colorado, by G. K. Gilbert, in Seventeenth Annual, Pt. II; Preliminary report on artesian waters of a portion of the Dakotas, by N. H. Darton, in Seventeenth Annual, Pt. II; Water resources of Illinois, by Frank Leverett, in Seventeenth Annual, Pt. II; Water resources of Indiana and Ohio, by Frank Leverett, in Eighteenth Annual, Pt. IV; New developments in well boring and irrigation in eastern South Dakota, by N. H. Darton, in Eighteenth Annual, Pt. IV; Rock waters of Ohio, by Edward Orton, in Nineteenth Annual, Pt. IV; Artesian-well prospects in the Atlantic coastal plain region, by N. H. Darton, Bulletin No. 138.

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THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

AUGUST, 1907.

O

Water-Supply Paper No. 217

Series { B, Descriptive Geology, 124
0, Underground Waters, 73

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

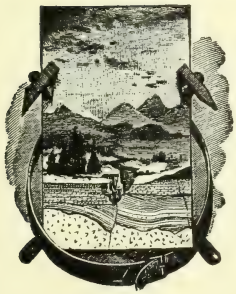
# WATER RESOURCES

OF

# BEAVER VALLEY, UTAH

BY

WILLIS T. LEE



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1908

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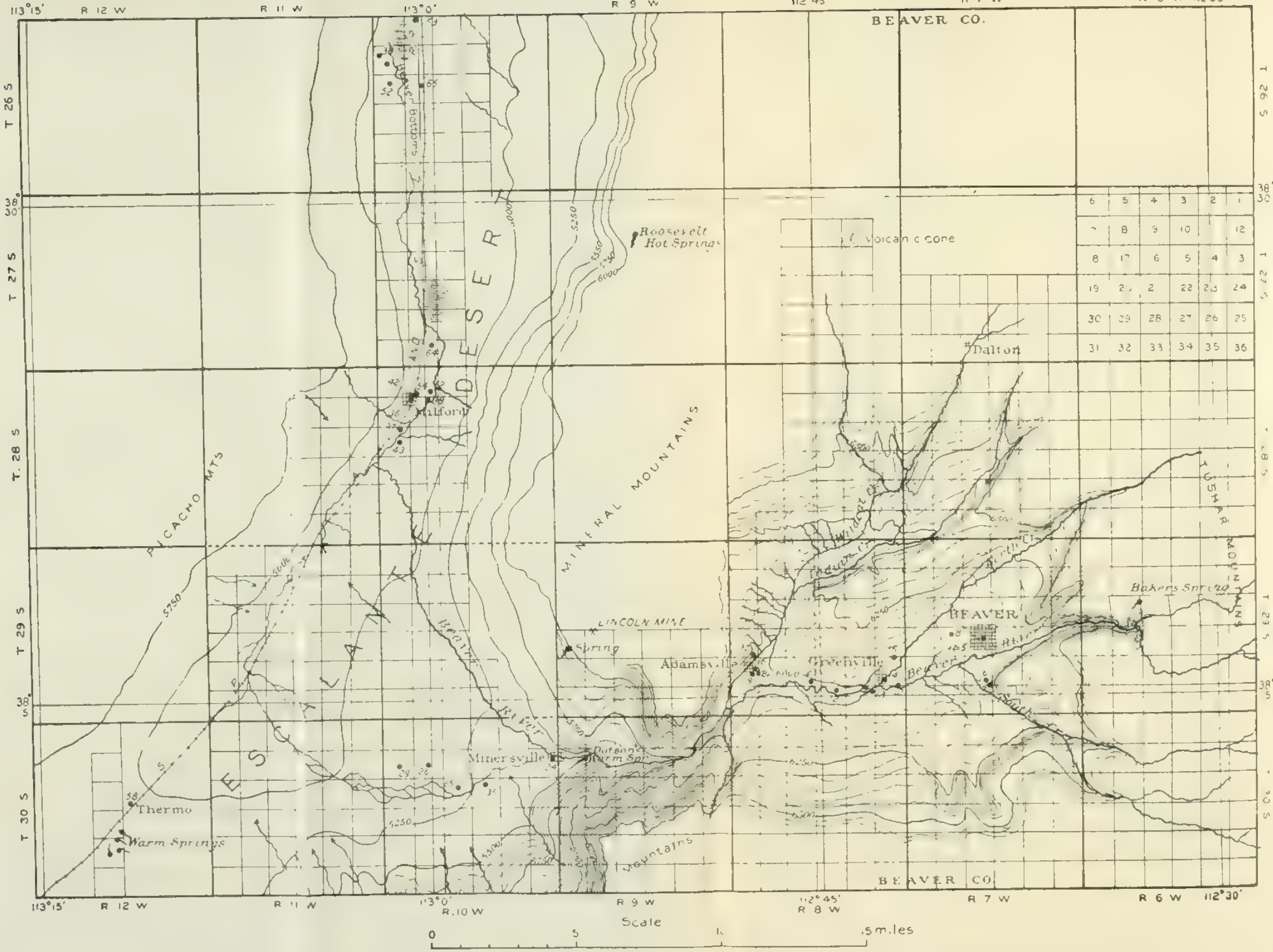


SKETCH MAP OF BEAVER VALLEY, IN BEAVER COUNTY, UTAH, SHOWING LOCATION OF PRINCIPAL SPRINGS AND DEEP WELLS.

# WATER RESOURCES OF BEAVER VALLEY, UTAH.

By Willis T. Lee.

## INTRODUCTION.

*Location and extent of area examined.*—Beaver Valley is located in Beaver County, in southwestern Utah, about 175 miles south of Salt Lake. It lies between the Tushar Mountains on the east and the Beaver Mountains on the west. The principal town of the valley is Beaver, which is most conveniently reached from Milford, a station on the San Pedro, Los Angeles and Salt Lake Railroad. The valley, together with its neighboring highlands, occupies the eastern third of Beaver County, an area of about 1,200 square miles. A large part of this area, however, is rocky upland and unproductive desert, the tillable land comprising a comparatively small area in the immediate vicinity of the streams.

*Purpose and scope of work.*—The purpose of this paper is to present information concerning the waters of Beaver Valley and to point out ways and means of increasing their usefulness.

The presence of a large amount of water in Beaver Valley results from local topograhic conditions, the water being supplied by precipitation in the highland to the east. Its conservation and distribution result from geologic conditions, the water being held in loose gravel and sand, which are more or less confined between ridges of consolidated rocks. The rock basins were formed partly by erosion and partly by faulting and surface deformation. In order to accomplish the purpose in view it is therefore necessary to describe the geographic and geologic conditions in Beaver Valley and neighboring regions.

The investigation included the determination of the flow of streams and springs, of the manner of occurrence and quantity of the underground waters as shown by the geologic and geographic conditions of the region and by the distribution of springs and wells, and of the chemical character of the waters with reference to their adaptability

to domestic use and to irrigation. The chemical data were obtained (*a*) by field assays, which are approximately correct and probably of sufficient accuracy to be of value in comparing the various waters; (*b*) by more exact analyses, some of which were made in the laboratory of the United States Geological Survey by W. M. Barr, and others by Herman Harms, State chemist of Utah, for the San Pedro, Los Angeles and Salt Lake Railroad; and (*c*) by sanitary analyses, made also by Herman Harms.

*Cooperation.*—The work was done during the summer of 1906, the United States Geological Survey cooperating with the State of Utah through Caleb Tanner, State engineer, and with the county of Beaver through the supervisors of the county. In collecting the information the writer was assisted by J. F. Hoyt, of Nephi, Utah.

## GEOGRAPHY.

Southwestern Utah is divided into two general provinces—the plateau province and the basin province. These are separated sharply by a succession of high cliffs extending in a northeasterly direction from St. George through Beaver and northward. At the foot of these cliffs are located the principal towns of the southwestern part of the State—for example, St. George, Toquerville, Kanarraville, Cedar City, Parowan, Beaver, and Fillmore. To the east of the cliffs lie the High Plateaus of Utah, well known through the writings of Dutton, Powell, Gilbert, and others; and to the west of them lie the barren deserts of the Great Basin.

### PLATEAU PROVINCE.

The High Plateaus lie at an elevation several thousand feet above the Great Basin, and isolated mountains of volcanic origin rise to altitudes considerably greater than that of the general surface of the plateaus, the highest in the vicinity of Beaver being Delano Peak, which has an altitude of 12,240 feet. These plateaus and mountains are of the greatest importance in considering the water supply, since owing to their altitude the rainfall is greater there than in the basin region to the west. The streams which yield the water supply of southwestern Utah all rise in the highlands of the plateaus.

### BASIN PROVINCE.

#### DESERTS.

The Great Basin consists of broad sandy deserts, from the surface of which rise more or less isolated groups of rock mountains. The Great Basin has been described by Gilbert[a] and others, who show

[a] Gilbert, G. K., Lake Bonneville: Mon. U. S. Geol. Survey, vol. 1, 1890.

that the lowest parts were formerly occupied by a lake known as Lake Bonneville, an outline of which is shown on the accompanying map (fig. 1). Sands, gravels, and clays were deposited in this lake to a great though unknown depth, filling the low places generally and transforming into nearly level plains large areas which may pre-

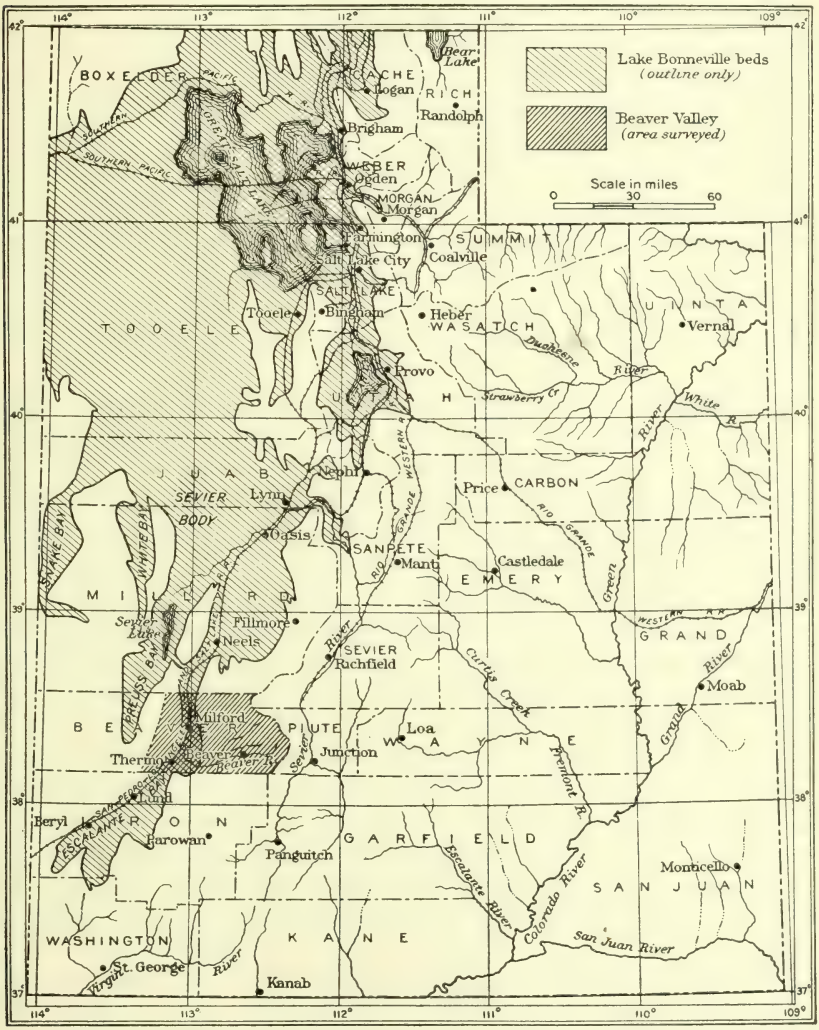


FIG. 1.—Map of Utah, showing location of Beaver Valley and outline of Lake Bonneville. (After G. K. Gilbert, Mon. U. S. Geol. Survey, vol. 1, 1890.)

viously have had very uneven surfaces. The Escalante Desert, a part of which lies within the region described in this paper, represents the southernmost extension of Lake Bonneville, called by Gilbert Escalante Bay. A comparatively narrow strait, here about 6 miles wide, connected Escalante Bay with the main body of Lake Bonne-

ville to the north. The bed of the old lake is now represented by the level bottom lands of the desert. Rock mountains rise abruptly from the plains, and material from the mountains, borne out by the streams and deposited as alluvial slopes and cones, from the gentle outwash slopes, characteristic of the desert region.

### ISOLATED BASINS.

Between the High Plateaus and the Escalante Desert there are several comparatively small basins, some at an elevation but little greater than that of the Escalante Desert, as Rush Lake Valley; others several hundred feet higher, as Parowan Valley, which is separated from the main desert by highlands except where they are cut by a narrow canyon through which the valley was formerly drained, but which is now dry; and Beaver Basin, 1,000 feet or more above the floor of the Escalante Desert, with which it is connected by a canyon at Minersville, carved by Beaver River through the Mineral Mountains.

These basins, as described in detail in the case of Beaver Basin, are partly filled with sediments similar to those of Lake Bonneville, from which it might be inferred that they were formerly small embayments of the lake that were later elevated to their present position by crustal movements. This inference finds some confirmation in recent earthquake disturbances that are known to have occurred in this region, and in the fact that the basins lie in a zone of profound faulting, which has been subject to the differential movements that have resulted in the great differences of elevation between the High Plateaus and the Great Basin. It seems more probable, however, that these basins formerly contained isolated lakes that were tributary to Lake Bonneville and lay at altitudes somewhere greater than the main lake, much as Utah Lake is tributary to Great Salt Lake at the present time. Beaver Basin, the only one of these small basins within the area described, will be referred to frequently, and for convenience the deposits filling it may be called the Beaver Lake beds and the body of water in which they were laid down may be called Beaver Lake.

### RESIDUAL LAKES.

In certain places where the water supply is sufficient the lower portions of the old lake bed still contain small salt lakes, such as Sevier Lake, Little Salt Lake in Parowan Valley, and Blue Lake near Deseret. In other places water gathers in the depressions during wet weather and forms mud flats, one of which, known as Beaver Bottoms, is within the area here described. Many parts of the Escalante Desert are so nearly level that rain water accumulates at

the surface and stands practically motionless until absorbed into the ground, and during wet weather much of the desert becomes an impassable bog.

### DRAINAGE.

The drainage with which this paper is concerned is entirely that of Beaver River and its tributaries. All the permanent streams entering the valley rise in the Tushar Mountains to the east, and the trunk stream of the system supplies the greater part of the water, since it has its origin in the highest part of the range among such lofty peaks as Delano (altitude 12,240 feet), Baldy (altitude 11,730 feet), and Belknap (altitude 12,200 feet). The main tributaries are South Creek, Burch Creek, North Creek, Indian Creek, and Wildcat Creek, all of which rise in the Tushar Mountains and join the river within Beaver Basin. There are no other tributaries having perennial flows, and after leaving Beaver Basin the river rapidly decreases in volume until at Milford it also becomes intermittent. Still farther to the north the trunk channel subdivides into the distributary channels of Beaver Bottoms. The river is nominally a part of the Sevier Lake drainage, but according to report it is only occasionally that a flood has sufficient volume to find its way into the lake.

The greater part of the water passing Minersville finds its way quickly into the sands and gravels of the Lake Bonneville beds. The sediments swept from the canyon are deposited upon the plain to the west of Minersville, forming a delta fan. The fan is so nearly flat and its surface is so regular, as compared with the outwash slopes of the mountains near by, that the delta character is inconspicuous. Its presence is made clear, however, by the distribution of the streams. Beaver River at the present time follows the northern edge of the delta, but the water diverted from the river at Minersville for the irrigation of the fields southwest of the town finds its way westward near the southern edge of the delta, gradually turning to the north and finally entering the river again about 2 miles south of Milford. The low ground obviously marks an abandoned course of Beaver River, and it would apparently require little effort, perhaps nothing more than a clogging of the present channel with débris during some flood, to turn it back into the old course.

## GEOLOGY.

### FORMATIONS.

#### GRANITE.

The oldest rocks exposed at the surface in the Beaver region are supposed to be the granites of the Mineral Mountains. They underlie and are apparently older than the Paleozoic sediments. They have

been subjected to comparatively recent movements, as is made evident by the occurrence of faults and zones of crushing and shearing and by the presence of hot springs in the shear zones. It is possible, however, that the granites, instead of being pre-Paleozoic in age, are due to comparatively recent intrusions. The region is one in which great crustal disturbances have taken place, as is indicated by the faulted and tilted sediments described on page 14 and by the great masses of extrusive rock found in the Tushar Mountains and elsewhere. The volcanic disturbances have occurred repeatedly, as shown by the alternation of early Tertiary lavas and sediments and the occurrence of basalt included within the Quaternary gravels and resting upon them in the form of sheets and volcanic cones.

*Section of rocks exposed in Beaver Canyon 4 miles east of Minersville.*

| | Feet. |
|---|---|
| 1. Basalt, several hundred feet. | |
| 2. Rhyolitic flows, tuffs and breccia, many hundred feet. | |
| 3. Andesitic flows, tuffs and breccia, several hundred feet. | |
| 4. Uncemented gravel and bowlders of limestone, quartzite, and andesite | 250 |
| 5. Coarse consolidated conglomerate consisting of limestone, quartzite, and various crystalline rocks, the bowlders having a maximum diameter of 5 feet | 90 |
| Unconformity. | |
| 6. Red shale | 60 |
| 7. Earthy-gray limestone | 15 |
| 8. Red shale | 10 |
| 9. Gray limestone | 10 |
| 10. Red shale and ripple-marked sandstones | 40 |
| 11. Blue limestone | 10 |
| 12. Red shale and ripple-marked sandstones | 120 |
| 13. Limestone containing *Aviculipecten weberensis*, *Aviculipecten* aff. *occidentalis*, *Myalina* aff. *perattenuata*, *Bakewellia* n. sp., *Pleurophorus sp.*, *Schizodus* sp | 15 |
| 14. Shale | 40 |
| 15. Limestone containing same fossils as No. 13 | 15 |
| 16. Buff shale with a subordinate amount of limestone | 95 |
| 17. Shale and limestone containing *Aviculipecten* n. sp., *Pleurotomaria?* sp., *Bakewellia* n. sp., *Naticopsis* sp., *Xenodiscus?* sp., undetermined ammonoids | 100 |
| 18. Red shale | 35 |
| 19. Yellowish brown shales alternating with ripple-marked sandstones | 40 |
| 20. Quartzitic basal conglomerate | 10 |
| Unconformity. | |
| 21. Cherty limestone containing *Zaphrentis?* sp., *Fistulipora* sp., *Septopora sp.*, *Productus* aff. *subhorridus*, *Meekella?* sp., *Spirifer* aff. *cameratus*, *Squamularia* aff. *perplexa*, *Spiriferina* aff. *kentuckyensis*, *Spiriferina* sp., *Composita* aff. *subtilita*, *Hustedia* aff. *meekana*, *Pugnax* aff. *osagensis* | 450 |
| 22. Yellowish quartzite | 200 |
| 23. Cherty limestone containing *Squamularia?* sp. and *Hustedia* aff. *meekana* | 500 |

Base not exposed where section was measured.

### PALEOZOIC SEDIMENTS.

A thick series of massive limestones overlies the granite and is well exposed in the Mineral Mountains north of Minersville. These limestones are overlain in turn by red sandstones, shale, and volcanic products, as shown in the section on the preceding page.

The massive cherty limestone at the base of the section is referred with little doubt to the Aubrey. The fossils were examined by George H. Girty, of the United States Geological Survey, who states that they probably belong in the Aubrey fauna, although many of the most characteristic forms of that fauna are wanting. The stratigraphic position and general field relations of the limestone show that it is probably the same as the typical Aubrey limestone of the Grand Canyon region farther to the south.

The red sediments overlying the cherty limestone yielded a number of well-preserved fossils which also have been examined by Doctor Girty, who states that the fauna is the same as that of the Permian beds of Walcott's[a] Grand Canyon section and of the "Permo-Carboniferous" of the Wasatch Mountains.

In Colob Plateau, about 50 miles south of Beaver, a thickness of more than 8,000 feet of strata was measured between the base of the Permian and the top of the Benton. Of this great thickness only 565 feet of the base of the Permian remain in Beaver Canyon, the upper beds having been eroded away. The red beds are overlain by a coarse conglomerate, presumably equivalent in age to the Eocene conglomerates of the plateaus, and these are covered in turn by extensive masses of volcanic rock.

### EFFUSIVE ROCKS.

The oldest of the lavas covering the red beds and the overlying conglomerate are dark-colored andesites. These are most conveniently seen in the Beaver region in the canyon east of Minersville. They consist of flow sheets, tuffs, and volcanic breccias and occur also as bowlders in the underlying conglomerate.

Above the andesites are extensive masses of light-pink to white rhyolite. These are especially large in the Tushar Mountains, where they occur as flow sheets, tuffs, and breccias, constituting a large part of the range. The rhyolites are best known locally as the soft pink rock found near the mouth of Beaver Canyon and elsewhere, that is used for building purposes. It is a fine-grained, consolidated rhyolitic tuff which, on account of its softness, is easily quarried and

[a] Walcott, C. D., The Permian and other Paleozoic groups of the Kanab Valley, Arizona: Am. Jour. Sci., 3d ser., vol. 20, 1880, pp. 221, 225.

dressed, but which is resistant enough to make a good building stone. In many places masses of this tuff are not well consolidated and resemble beds of light-colored sand and clay.

After some, at least, and probably after all of the rhyolites of this region had been extruded they were extensively eroded, as shown by the occurrence of beds of conglomerate made up largely of pebbles and bowlders of rhyolite. These conglomerates of rhyolite occur in Beaver Canyon at Minersville, in Bakers Canyon, 5 miles east of Beaver, and elsewhere. At Minersville they are well stratified, but consist mainly of angular fragments of rhyolite. In Bakers Canyon they are several hundred feet thick and made up of well-rounded pebbles and bowlders of many kinds of rock, the largest bowlders consisting of rhyolite.

Basalt overlies the rhyolitic rocks and rests in some places upon the conglomerates and in others upon the tuffs and breccias. The basalt is the black rock used to a considerable extent as a building stone in Beaver Valley. It occurs in sheets near the mouth of Beaver Canyon, in the canyon east of Minersville, in Black Mountain north of Beaver, and elsewhere. It also forms the volcanic cones, one of which is located 13 miles north of Beaver and another 20 miles north of Beaver near the Cove Creek sulphur beds.

### YOUNGER SEDIMENTS.

The sediments to the west and north of Minersville, the only part of the Escalante Desert within the region here described, constitute a part of the Lake Bonneville beds. The Escalante Desert, an outline of which is shown in fig. 1 (p. 7), has a general elevation greater than that of the main part of the old lake basin and was included in the lake as Escalante Bay, at least during the closing stages of sedimentation, only during the maximum extension of the lake, as shown in Gilbert's map, Pl. XIII of the Bonneville monograph. For this reason the shore lines, so conspicuous along the mountain sides in the vicinity of Salt Lake, are practically absent in the vicinity of Milford, the altitude of the more conspicuous ones near Salt Lake being less than that of the surface of the Escalante Desert. For the same reason the wave-built terraces are not so conspicuous as they are in other places, although they occur as low sand and gravel benches at a greater or less distance from the hills and in many places near the center of the desert.

The lack of vertical exposures of any considerable thickness renders impossible a detailed description of the sediments except those near the surface. Such well records as are available, however, show that the beds consist principally of clay and fine sand with a subordinate amount of gravel. The wells at Thermo and Milford, the

drillers' records of which are given on pages 29, 32, are within the area described and give the most exact information available regarding the character of the Lake Bonneville beds in Beaver County.

The maximum thickness of these beds is not known. The only well that penetrates through them is located at Neels, and shows a thickness of sediment of nearly 2,000 feet. It is possible that the lower parts of these sediments may be of pre-Bonneville age, but there is no indication in the driller's record (given on p. 33) that they do not all belong to the Lake Bonneville beds. It is noteworthy also that Neels is located in a narrow strait of Lake Bonneville, and it is altogether probable that in the broader parts of the basin the sediments may be much thicker.

The sediments of Beaver Basin consist of unconsolidated clay, sand, and gravel in alternating layers, as shown in detail in the well records (pp. 23–26). Their character and distribution, as well as their similarity to the Lake Bonneville beds, seems to warrant the inference that they are lake deposits. A thickness of several hundred feet is exposed in the mesas near Beaver, and an additional thickness of nearly 500 feet is shown by the wells, but the total depth of the sediments within Beaver Basin is not known.

The Beaver Lake beds are similar to the Lake Bonneville beds in general character, degree of consolidation, and association with flows of basalt. For these reasons the Beaver Lake beds are believed to be of the same age as the Lake Bonneville beds, although they lie at an elevation 1,000 feet or more above the Lake Bonneville sediments of the Escalante Desert. This difference in elevation, as previously suggested, may be due to recent elevation, but is more probably to be accounted for as the result of deposition in a lake tributary to Lake Bonneville and lying at a greater elevation.

## STRUCTURE.

The geologic structure in the Beaver region is somewhat difficult to make out owing to the occurrence of the great quantities of eruptive rock and to the recent accumulation of sediments—the Beaver Lake and the Lake Bonneville beds—which cover or obscure the faults. Farther south, however, the older sedimentary rocks are better exposed and their structural relations are plainly discernible.

Along the western border of the High Plateaus of Utah, between Beaver and St. George, several basins have been formed apparently by faulting and the displacement of large crust blocks. Rush Lake Valley (or Cedar Valley, as it is sometimes called) and Parowan Valley are perhaps the most conspicuous of these basins. The strata of the plateaus to the east lie essentially horizontal, except where faulted blocks have been displaced, but the same formations to the west of

the cliffs that form the western margin of the plateaus dip eastward beneath the basins. In order to avoid possible misunderstanding, it should be noted in this connection that the hills west of Parowan, mapped by Dutton[a] as trachyte and rhyolite, were found to consist mainly of sandstones and conglomerates similar to those of the plateau east of Parowan, which, as stated by the same author, are sediments of Cretaceous and Tertiary age.

The fault at which the great displacements occurred to form these basins is known as the Hurricane fault, and the northward extension of the Hurricane ledge of the plateau region of southern Utah forms the western margin of the plateaus in Cedar and Parowan valleys. The Hurricane fault, or the zone of faulting in which it occurs, is traceable from the Grand Canyon northward to the lava fields between Parowan and Beaver valleys, where it could not be followed through the effusive rocks. But a number of facts indicate that Beaver Basin, like Parowan Valley, was formed by faulting and crust-block tilting. Among these facts are the following:

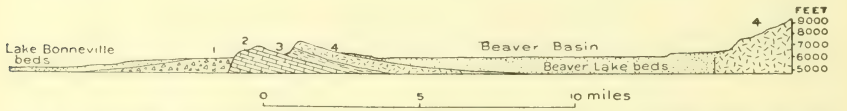


FIG. 2.—East-west section through Beaver, showing structure of Beaver Basin and relation of Beaver Lake beds to Lake Bonneville beds. 1, Volcanic breccia (Tertiary); 2, Aubrey limestone (Carboniferous); 3, red sandstone and shale (Permian); 4, andesite and rhyolite.

The sedimentary formations of the plateau region occur in the Tushar Mountains beneath the igneous rocks. They are exposed, according to Dutton,[b] in the eastern flanks of these mountains and are said to occur also in the western flanks in small detached blocks, one of which, at least, is limestone from which lime is obtained for local uses. The writer did not see these sediments, but in the Mineral Mountains the Paleozoic formations, a section of which is given on page 10, were observed dipping steeply to the east and passing underneath lavas identical in kind and constitution with those of Tushar Mountains. These in turn are finally buried by the sands and gravels of the Beaver Lake beds. The sedimentary rocks terminate abruptly at the west against the breccias composed of volcanic rock which have been described as younger than the rhyolites. This is evidently due to the presence of a fault along the western face of the Mineral Mountains. The probable structural relations are shown in the sketch section, fig. 2.

[a] Dutton, C. E., Tertiary history of the Grand Canyon district: Mon. U. S. Geol. Survey, vol. 2, 1882, atlas sheet No. 21.

[b] Dutton, C. E., Geology of the High Plateaus of Utah, 1880, atlas sheet No. 6, sec. No. 4.

Further evidence that Beaver Basin is in a zone of faulting is found in the prevalence of earthquakes. A number of severe shocks have occurred within recent years, the zone of greatest disturbance following in general the fault zone at the edge of the plateau. In this same zone also occur the volcanic cones north of Beaver, the beds of sulphur at Sulphurdale that have been described by the writer[a] as being still in process of accumulation, and numerous large springs, some of which yield waters that are hot and highly mineralized.

## WATER SUPPLY.

### PRECIPITATION.

Few rainfall records sufficiently complete to be of great use are available from southern Utah. Those that are close enough to the region here described to indicate the precipitation in this region are given below. From these records, representing 11 stations, it appears that the average rainfall, computed from the 78 complete yearly records only, is 10.81 inches.

TABLE 1.—*Records of precipitation at stations in southwestern Utah.*

BEAVER. (ALTITUDE, 5,970 FEET.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1889 | ------ | ------ | ------ | ------ | 1.20 | 0.86 | 0.38 | 1.93 | 0.40 | 1.62 | 0.14 | 3.79 | ------ |
| 1890 | 1.03 | 0.67 | 0.53 | 0.60 | .12 | Tr. | .51 | .44 | 1.22 | .17 | .27 | .50 | 6.06 |
| 1891 | .41 | 1.17 | .33 | 1.09 | .61 | 1.14 | 1.36 | 1.25 | 1.24 | Tr. | .00 | 1.50 | 10.10 |
| 1892 | .81 | ------ | 1.17 | 1.12 | ------ | .10 | 1.20 | ------ | ------ | ------ | ------ | 1.75 | ------ |
| 1893 | .45 | 1.38 | 1.45 | 2.04 | .50 | .00 | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 1904[a] | ------ | ------ | ------ | ------ | ------ | ------ | 1.20 | 1.13 | .38 | .67 | .00 | .40 | ------ |
| 1905 | .06 | 2.35 | 1.34 | 1.13 | 2.49 | .00 | .47 | .95 | 2.07 | .30 | .85 | .20 | 12.21 |
| 1906 | 1.10 | 1.09 | 3.59 | 1.62 | 1.86 | ------ | ------ | 2.04 | 1.27 | ------ | .85 | ------ | ------ |

[a] Ten years' record wanting.

BLACKROCK. (ALTITUDE, 4,872 FEET.)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1901 | 0.40 | 1.43 | 0.34 | 1.29 | 0.78 | 0.94 | 0.15 | 1.02 | 0.00 | 0.56 | Tr. | 0.70 | 7.61 |
| 1902 | .26 | .20 | 1.15 | .16 | .23 | Tr. | .40 | .19 | .84 | .53 | 1.97 | .45 | 6.38 |
| 1903 | 1.11 | 1.30 | 2.00 | 2.59 | 1.72 | .33 | .41 | 1.75 | .92 | .95 | .10 | .18 | 13.36 |
| 1904 | 4.10 | 1.00 | .93 | .26 | 1.64 | .04 | .05 | .56 | .30 | .65 | .00 | .55 | 6.39 |
| 1905 | .48 | 2.26 | 1.74 | 1.28 | 1.52 | Tr. | .65 | .75 | 2.57 | .88 | ------ | ------ | ------ |
| 1906 | 1.59 | ------ | ------ | 3.31 | .91 | .12 | ------ | 1.12 | 2.33 | .03 | 2.11 | .97 | ------ |

DESERET. (ALTITUDE, 4,541 FEET.)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1891 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0.64 | 0.62 | 0.05 | 0.00 | 0.21 | ------ |
| 1892 | 0.53 | 1.30 | 1.84 | 0.71 | 1.81 | 0.14 | 0.42 | .58 | .06 | 1.12 | .10 | .85 | 9.47 |
| 1893 | .54 | .61 | 1.85 | 1.40 | .67 | .00 | .21 | .91 | .46 | .05 | .14 | .82 | 7.66 |
| 1894 | .35 | 1.35 | .53 | .64 | .43 | 1.29 | .25 | .23 | 1.67 | .39 | .00 | .88 | 8.01 |
| 1895 | .40 | .53 | .63 | .84 | ------ | Tr. | Tr. | Tr. | .80 | .45 | .84 | .38 | ------ |
| 1896 | .32 | ------ | .29 | .47 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 1899 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | Tr. | 1.23 | .34 | .80 | ------ |
| 1900 | .36 | .05 | Tr. | 2.85 | .10 | .03 | Tr. | Tr. | 1.12 | .39 | .48 | .00 | 5.38 |
| 1901 | .10 | 1.67 | .80 | 1.02 | 1.90 | .62 | .03 | 1.54 | .03 | .50 | .04 | .76 | 9.01 |
| 1902 | .48 | .30 | .82 | .36 | .32 | Tr. | .08 | .04 | .40 | .20 | 1.65 | .20 | 4.85 |
| 1903 | .94 | 1.30 | .40 | .90 | 1.53 | .40 | Tr. | .08 | .67 | .72 | Tr. | .05 | 6.99 |
| 1904 | .15 | .97 | 1.55 | .13 | 2.13 | .60 | Tr. | .20 | .32 | .32 | .00 | .77 | 7.14 |
| 1905 | .42 | 1.25 | 1.06 | 1.36 | 1.35 | .00 | .00 | 1.15 | 1.79 | Tr. | 1.25 | .13 | 9.76 |
| 1906 | .31 | .41 | 2.10 | 1.63 | 1.06 | .19 | ------ | .63 | .95 | Tr. | 1.38 | .94 | 11.77 |

[a] Bull. U. S. Geol. Survey No. 315, 1907, pp. 485–489.

TABLE 1.—*Records of precipitation at stations in southwestern Utah*—Continued.

FILLMORE. (ALTITUDE, 5,100 FEET.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1892 | ------ | ------ | ------ | 2.11 | 2.03 | 0.82 | 0.29 | 0.47 | 0.06 | 1.07 | 0.53 | 1.20 | ------ |
| 1893 | 0.81 | 1.51 | 2.89 | 2.09 | 1.53 | .00 | .48 | 1.71 | 1.21 | .46 | 1.11 | 1.79 | 15.59 |
| 1894 | .70 | .56 | 1.04 | 2.43 | .64 | 2.04 | .34 | 1.19 | 1.94 | .41 | .31 | 1.77 | 13.37 |
| 1895 | 1.93 | 2.15 | 2.06 | 1.23 | 1.51 | .80 | .56 | .97 | 1.66 | .93 | 1.46 | 1.10 | 16.36 |
| 1896 | .75 | .16 | .94 | 1.47 | 1.06 | .01 | 2.36 | 1.69 | .85 | .37 | 1.17 | .33 | 11.16 |
| 1897 | 2.15 | 2.17 | 2.89 | 1.26 | .03 | .26 | .19 | .31 | 1.50 | 3.59 | 1.15 | 1.55 | 17.04 |
| 1898 | .15 | 1.20 | 3.07 | .59 | 4.44 | .96 | .99 | .06 | Tr. | .60 | 1.27 | .76 | 14.59 |
| 1899 | .50 | 1.40 | 5.00 | 1.45 | .85 | .96 | .01 | .28 | .00 | 1.94 | 1.06 | 1.03 | 14.48 |
| 1900 | 1.25 | .45 | .15 | 3.18 | .35 | .60 | Tr. | .14 | 1.58 | .93 | .66 | .03 | 9.32 |
| 1901 | .35 | 2.00 | 1.54 | 2.35 | 1.92 | .57 | .41 | .90 | .00 | .72 | .15 | 1.97 | 12.88 |
| 1902 | 1.03 | 1.03 | 2.59 | .36 | .90 | .09 | .49 | .16 | 1.51 | .58 | 2.70 | .46 | 11.90 |
| 1903 | 1.44 | 1.26 | 1.19 | 2.66 | 2.27 | .04 | .27 | .38 | 1.00 | 1.06 | .00 | .40 | 11.97 |
| 1904 | 1.89 | 1.90 | 2.16 | .26 | 2.81 | .25 | .07 | 1.13 | .10 | .62 | .00 | .95 | 12.14 |
| 1905 | .90 | 2.48 | 2.66 | 1.53 | 2.45 | Tr. | .53 | .62 | 2.81 | .51 | 1.13 | .54 | 16.16 |
| 1906 | .72 | 1.16 | 3.88 | 4.38 | 2.18 | .40 | 1.27 | 1.20 | 2.38 | .15 | 2.93 | .63 | 21.28 |

FRISCO. (Altitude, 6,250 feet.)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1897 | ------ | 0.30 | 0.44 | Tr. | 0.20 | 0.11 | 0.16 | 0.19 | 1.21 | 1.50 | 0.45 | 1.00 | ------ |
| 1898 | 0.42 | .10 | .12 | 0.41 | 2.59 | .11 | .97 | 1.46 | .00 | .31 | .15 | .24 | 6.88 |
| 1899 | .10 | .65 | 2.56 | 1.01 | .08 | .36 | .81 | .18 | Tr. | .51 | .28 | Tr. | 6.54 |
| 1900 | .11 | .04 | .03 | 1.73 | ------ | .04 | Tr. | .05 | 1.41 | .77 | .55 | .05 | ------ |
| 1901 | .35 | 2.36 | .28 | .86 | 1.42 | .97 | 1.76 | .64 | Tr. | .68 | Tr. | .75 | 10.07 |
| 1902 | .95 | .02 | .72 | .10 | Tr. | Tr. | .74 | .82 | .47 | .15 | 1.22 | .39 | 5.58 |
| 1903 | .75 | 1.66 | .68 | 1.49 | 1.88 | .66 | .72 | 1.12 | .82 | .85 | .02 | .07 | 10.72 |
| 1904 | .50 | .64 | .97 | .10 | 2.49 | .11 | .86 | .83 | .45 | .41 | .00 | .22 | 7.58 |
| 1905 | .66 | 1.44 | 1.71 | .58 | 1.44 | .02 | .58 | 1.04 | 2.32 | .89 | .83 | .30 | 11.81 |
| 1906 | .10 | .56 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | .98 | .95 | ------ |

GARRISON.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 0.66 | 0.60 | 0.20 | 0.38 | 1.16 | 0.54 | 0.05 | 0.55 | 0.38 | 0.23 | Tr. | Tr. | 4.75 |
| 1904 | .07 | 1.49 | .62 | .06 | .97 | .41 | .93 | .95 | .55 | .94 | 0.00 | 0.22 | 7.21 |
| 1905 | .37 | 1.30 | .30 | .99 | 1.83 | Tr. | .10 | .83 | .85 | .00 | 2.14 | .11 | 8.82 |
| 1906 | ------ | Tr. | 2.47 | 1.58 | .77 | .06 | .33 | ------ | .50 | .10 | 1.98 | .58 | ------ |

MINERSVILLE.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1897 | ------ | 1.75 | 2.40 | 0.16 | 0.28 | 0.03 | 0.91 | 0.49 | 2.07 | 1.57 | 0.49 | 1.52 | ------ |
| 1898 | 1.49 | .57 | 2.08 | .25 | 2.35 | .46 | .51 | .94 | .11 | .08 | .66 | .29 | 9.79 |
| 1899 | .57 | .38 | 2.40 | .71 | .65 | .17 | 1.20 | .63 | Tr. | 1.38 | .52 | .63 | 9.24 |
| 1900 | .34 | .20 | .34 | 2.32 | .32 | .13 | .04 | ------ | ------ | .62 | 1.33 | .05 | ------ |
| 1901 | .45 | 2.21 | .51 | .87 | 1.05 | .55 | .86 | 1.60 | .02 | .70 | .16 | .72 | 9.70 |
| 1902 | .91 | .29 | 1.22 | .12 | .07 | ------ | .41 | .48 | .97 | .10 | 2.70 | ------ | ------ |
| 1903 | .14 | .94 | 1.10 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | .00 | ------ |
| 1904 | .70 | 1.70 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | Tr. | .00 | .80 | ------ |

MODENA. (ALTITUDE, 5,479 FEET.)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1902 | 0.33 | 0.32 | 0.54 | 0.13 | 0.19 | 0.02 | Tr. | 1.58 | 0.76 | 0.04 | 0.89 | 0.29 | 5.09 |
| 1903 | .12 | .85 | .74 | .61 | .55 | .13 | 0.14 | .92 | 1.48 | 1.39 | .00 | .00 | 6.93 |
| 1904 | .20 | 1.01 | .98 | .02 | 1.55 | .11 | .69 | 1.52 | 2.02 | .50 | .00 | .23 | 9.83 |
| 1905 | .86 | 1.79 | 2.09 | 1.05 | .72 | Tr. | .81 | 1.71 | 1.26 | 1.00 | .90 | .20 | 12.39 |
| 1906 | .67 | .47 | 3.22 | 2.91 | 1.31 | .00 | 2.30 | 3.40 | .91 | .34 | 1.40 | 2.13 | 19.06 |

PAROWAN. (ALTITUDE, 5,970 FEET.)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1890 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0.93 | 0.59 | 0.43 | 0.34 | ------ |
| 1891 | 1.46 | 2.07 | 2.57 | 1.57 | 1.14 | 0.20 | 1.24 | 0.76 | 2.10 | .00 | .00 | 1.13 | 14.24 |
| 1892 | .47 | 1.03 | 1.79 | 2.03 | .83 | .04 | .66 | 1.24 | .00 | 2.32 | .20 | .39 | 11.00 |
| 1893 | .84 | 1.03 | 1.23 | 1.42 | 1.34 | .00 | 2.08 | 1.65 | 1.11 | Tr. | 1.38 | .72 | 12.80 |
| 1894 | 1.65 | .85 | 2.65 | 1.27 | .55 | .57 | .78 | 1.40 | .72 | .65 | Tr. | 1.88 | 12.97 |
| 1895 | 1.94 | 2.82 | 1.93 | .47 | .87 | .06 | .70 | .23 | .29 | .58 | 1.28 | .90 | 12.07 |
| 1896 | .16 | .48 | .71 | .83 | .93 | .08 | 1.69 | 3.00 | .47 | .36 | .30 | .16 | 9.17 |
| 1897 | 1.50 | 3.45 | 3.76 | .95 | .51 | .02 | .79 | 1.56 | 1.84 | 2.48 | .73 | .88 | 18.47 |
| 1898 | 1.99 | 1.20 | 1.66 | .64 | 3.35 | .24 | 1.19 | 1.46 | .25 | .30 | .72 | .82 | 13.82 |
| 1899 | .12 | 1.10 | 2.18 | 1.20 | 1.19 | .82 | .72 | .82 | .08 | .78 | .31 | 1.60 | 10.92 |

TABLE 1.—*Records of precipitation at stations in southwestern Utah*—Continued.

PAROWAN. (ALTITUDE, 5,970 FEET)—Continued.

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1900 | .51 | .23 | .18 | 2.64 | .61 | .13 | .11 | .84 | .82 | .56 | .34 | .07 | 7.04 |
| 1901 | .63 | 1.84 | .85 | 1.61 | .88 | .50 | .04 | 3.35 | .04 | .32 | .03 | .96 | 11.05 |
| 1902 | 1.18 | .31 | 1.83 | .21 | .18 | .06 | .49 | .76 | .50 | .61 | 1.86 | 1.03 | 9.02 |
| 1903 | 1.10 | .77 | 1.94 | 1.66 | 1.10 | .49 | .41 | 1.46 | 1.00 | 2.03 | Tr. | .53 | 11.89 |
| 1904 | .43 | 1.46 | 2.11 | 1.27 | 2.07 | .07 | .98 | 1.23 | .17 | .74 | Tr. | .79 | 11.32 |
| 1905 | .52 | 1.54 | 2.29 | .66 | 1.99 | Tr. | .75 | .37 | 3.80 | .12 | 1.11 | .32 | 13.47 |
| 1906 | 1.4 | .93 | 3.99 | 1.95 | .62 | Tr. | 1.71 | 3.10 | 3.49 | .41 | 2.09 | 1.18 | 20.87 |

PINTO. (ALTITUDE, 5,907 FEET.)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1897 | ------ | 3.05 | 4.11 | 0.78 | 0.52 | 0.05 | 0.90 | 0.89 | 2.17 | 3.76 | 0.40 | 1.16 | ------ |
| 1898 | 1.28 | .68 | 1.33 | .39 | 2.30 | .25 | .07 | .60 | .00 | .00 | .11 | .11 | 7.12 |
| 1899 | .25 | .35 | 2.17 | .40 | .58 | .77 | .05 | 1.06 | .00 | 1.75 | .67 | .49 | 8.54 |
| 1900 | .38 | .27 | .34 | 2.31 | .65 | .25 | .13 | .08 | 1.32 | .77 | 3.16 | .05 | 9.71 |
| 1901 | 1.72 | 2.74 | .23 | .85 | .85 | .45 | .80 | 5.07 | .00 | 1.43 | .39 | .57 | 15.10 |
| 1902 | .61 | .95 | 2.66 | .25 | .19 | Tr. | .01 | 1.71 | .20 | .93 | 3.09 | 70 | 11.30 |
| 1903 | .93 | 1.06 | 1.57 | 1.30 | .80 | .17 | Tr. | 1.74 | 1.37 | 1.75 | .00 | .21 | 10.40 |
| 1904 | .80 | 1.91 | 1.72 | .44 | 1.90 | ------ | 3.25 | 1.97 | .99 | .91 | .00 | .17 | ------ |
| 1905 | .64 | 1.88 | 2.28 | 1.48 | 2.09 | .00 | 1.41 | 1.83 | 4.82 | .77 | 1.67 | .08 | 18.95 |
| 1906 | 2.72 | 1.52 | 6.45 | 2.15 | .93 | .17 | 1.64 | 2.82 | 1.82 | .10 | 2.43 | 2.85 | 25.60 |

PIOCHE, NEV.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1877 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0.18 | 0.16 | 0.48 | 0.00 | 0.95 | ------ |
| 1878 | 0.46 | 1.67 | 0.73 | 1.31 | 1.27 | 0.04 | 0.29 | .97 | .22 | .35 | .63 | .42 | 8.36 |
| 1879 | 1.12 | .17 | .12 | 1.68 | .03 | .40 | .17 | .46 | .00 | .66 | .38 | 1.75 | 6.94 |
| 1880 | .21 | .36 | .12 | .46 | .01 | .03 | .18 | .47 | .18 | .52 | .29 | 1.84 | 4.67 |
| 1881 | .47 | .29 | .47 | 1.08 | .21 | .03 | .23 | 1.73 | .00 | .56 | .10 | .08 | 5.25 |
| 1882 | .38 | .55 | .30 | .98 | .29 | 3.23 | .21 | .95 | .03 | .60 | .71 | .08 | 8.31 |
| 1883 | .20 | .28 | .59 | 1.15 | .33 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |

## SURFACE WATERS.

### SOURCE.

The waters of Beaver Valley are derived almost entirely from the Tushar Mountains and result directly from the heavy precipitation about the lofty peaks, from which they enter the valley as streams. The rate of run-off from the mountains is regulated by the porous condition of the rocks and by the accumulations of snow. The elevation is such that the snow which falls during the winter melts gradually and feeds the streams during the spring and early part of the summer. The loose volcanic tuffs and breccias absorb large quantities of the water derived both from the rainfall and from the melting snows, and these waters are held back because of their slow movement through the rocks and finally issue in the form of springs having a comparatively regular flow. This conservation of the waters is of the greatest importance to the agricultural regions dependent upon the run-off and will be greatly enhanced by the forest reserve which has recently been established in the Tushar Mountains.

## MEASUREMENTS OF FLOW.

Little is known thus far of the actual quantity of water entering Beaver Valley. The settlement of the valley has taken place gradually, the first settlers appropriating all the water they wanted and the later ones taking what they could get. All the summer flow has long since been appropriated, although much of it is misused.

There is imperfect adjudication of rights and little knowledge of the actual volume appropriated in any particular case. The canals and ditches are poorly constructed. In some of them the water flows too rapidly and actively erodes the beds, thus increasing the volume carried. Others have not fall enough and the water fills them with silt, thus decreasing the volume carried. The amount of irrigated land is approximately as follows:

From Beaver River, 9,500 acres, of which 4,036 acres are supplied only during high water.

From South Creek, about 200 acres.

From North Creek, about 1,297 acres.

From Indian Creek, about 363 acres.

Total acreage in Beaver Valley, 11,360.

No measurements were obtained from Milford or from Beaver Bottoms. The only consecutive measurements of volume of the streams that have been made are given in the following table, the four streams named yielding practically the entire inflow:

TABLE 2.—*Discharge measurements of Beaver River and tributaries, in acre-feet.*

| Stream. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. |
|---|---|---|---|---|---|---|---|
| 1905.[a] | | | | | | | |
| Beaver River | 1,994 | 1,493 | 2,460 | 4,046 | 5,341 | 4,327 | 2,446 |
| North Creek | 129 | 122 | 166 | 196 | 228 | 304 | 344 |
| South Creek | 92 | 78 | 123 | 167 | 197 | 232 | 258 |

| Stream. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|
| 1905.[a] | | | | | | |
| Beaver River | 2,255 | 1,912 | 1,824 | 1,892 | 2,047 | 31,827 |
| North Creek | 332 | 274 | 240 | 161 | 135 | 2,631 |
| South Creek | 234 | 214 | 184 | 131 | 129 | 2,039 |

| Stream. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|
| 1906.[b] | | | | |
| Beaver River, June 15 to Sept. 22 | 9,520 | 7,190 | 4,600 | 2,450 |
| Indian Creek, June 26 to Aug. 31 | 182 | 578 | 314 | ------ |
| North Creek, June 16 to Sept. 27 | 3,510 | 2,728 | 1,556 | 1,382 |
| Canal at Minersville, June 21 to Sept. 21 | 847 | 2,290 | 2,070 | 1,570 |

[a] From weir measurements by L. L. Nunn, for the Telluride Power Company.
[b] Measurements by J. F. Hoyt.

### UTILIZATION.

The surface waters are all diverted for irrigation during the summer, but the winter flow is not utilized, although some opportunity is offered for the construction of storage reservoirs. One small dam has been built by the water users of Minersville, across Beaver River in the canyon, 5 miles east of the town, but the reservoir is too small to hold the waters of even a moderate-sized flood. It might be enlarged, however, at comparatively slight cost and its usefulness greatly increased.

## UNDERGROUND WATERS.

### SPRINGS.

*Number and distribution.*—A large number of springs occur in Beaver Valley, some in the consolidated rock formations, but most of them in the unconsolidated sediments of the Beaver Lake beds. In the vicinity of Beaver they are especially numerous and some of them are not distinguishable from the seepage where the return waters of the underflow produce swampy conditions over considerable areas. They are most numerous at the foot of the gravel benches, especially where the benches are irrigated, as east of Beaver, where the return water produces a continuous flow along the foot of the bench during the irrigation season, as shown in fig. 3 (p. 48). A few of the springs have peculiarities worthy of special description, but the essential facts regarding most of them are contained in Table 6 (p. 44).

*Sulphurdale.*—Sulphurdale is located about 20 miles north of Beaver, a little beyond the northern border of the area shown on the map (Pl. I). The sulphur deposits, locally known as the Cove Creek beds, are located at this place. Small quantities of water which would ordinarily reach the surface as a spring, but which on account of the mining operations carried on there may be classed as mine water, issue from the sulphur beds. The water is highly mineralized, as shown by the subjoined analysis, sulphites, sulphuric acid, and iron being especially abundant. Sulphureted hydrogen ($H_2S$) escapes from the beds in great quantities, and the sulphuric acid is apparently the result of the oxidation of this gas. The oxygen of the air first combines with the hydrogen (H), leaving the sulphur (S), most of which remains in the solid state and constitutes the sulphur deposits; but some of the sulphur is still further oxidized to sulphur trioxide ($SO_3$), which combines with water ($H_2O$) to form sulphuric acid ($H_2SO_4$).

*Analysis of water from Cove Creek sulphur beds.*

[Parts per million. Analyst, W. M. Barr.]

| | |
|---|---|
| Dissolved solids at 180° | 8,816 |
| Dissolved solids at 130° | 10,810 |
| Suspended matter | 52 |
| Silica ($SiO_2$) | 124 |
| Ferrous iron (FeO) | 560 |
| Ferric iron ($Fe_2O_3$) | 802 |
| Aluminum (Al) | 0 |
| Calcium (Ca) | 158 |
| Magnesium (Mg) | 232 |
| Sodium (Na) + Potassium (K) | 144 |
| Carbonate radicle ($CO_3$) | 0 |
| Bicarbonate radicle ($HCO_3$) | 0 |
| Sulphate radicle ($SO_4$) | 7,602 |
| Free sulphuric acid ($H_2SO_4$) | 4,523 |
| Chlorine (Cl) | 79 |
| Nitric radicle ($NO_3$) | 1.7 |
| Free sulphur (S) | 3.6 |

Constant loss of dissolved solids occurs when heated above 130°. Heated at 180°, not constant. Sample had free hydrogen sulphide ($H_2S$) when collected, with possible presence of sulphur dioxide ($SO_2$).

*McKean's spring* (Roosevelt Hot Spring; sec. ?, T. 27 S., R. 9 W.)—P. B. McKean's hot springs, of which there are several, are located on the western slope of the Mineral Mountains, northeast of Milford. The largest of these springs, having a discharge of about 10 gallons per minute, has been improved and a bath house built, to utilize the water for medicinal purposes. The spring is inclosed, so that the temperature of the water as it issues from the rock could not be measured, but as it issues from the pipe leading from the spring it has a temperature of 190° F. Within the spring the water is boiling and steam escapes also from crevices in the rock for a distance of several feet about the spring. The water contains a large amount of mineral in solution, as shown by the analysis in Table 9 (p. 50), and is strongly charged with hydrogen sulphide ($H_2S$). Much of the silica ($SiO_2$) contained in solution as the boiling water issues from the rocks is deposited as the water cools and does not appear in the analysis. The silica is precipitated as a light-green jelly which changes to white, spongy masses when artificially dried, but which in nature builds about the springs compact stony mounds. On analysis this deposit was found to consist entirely of silica.

The origin of the heat at this place is a matter of considerable interest. The springs are in the zone of faulting which follows the western face of the Mineral Mountains and which, although wholly in crystalline rock at this place, is well marked by a conspicuous

shearing and brecciation of the rock. On the mountain slope to the east is a mass of black obsidian of recent origin, and on the eastern flank of the range occur the volcanic cones which still retain their original form in great perfection. The heat may be caused by the friction or by the crushing of rock in the fault zone or may be residual heat from a mass of intrusive lava.

*Spring 4 miles north of Minersville.*—This spring, like the Roosevelt Hot Spring, is located on the western slope of the Mineral Mountains in the zone of faulting. It has deposited large quantities of mineral matter, presumably silica, building up a mound subcircular in outline and about a quarter of a mile in diameter, but the water, unlike that of the Roosevelt Spring, is not notably warmer than that of ordinary springs. The water issues from the mound at several points. The flow from the main opening was estimated at 50 gallons per minute, but the total flow was not determined.

The presence of warm springs in the zone of faulting to the north at the Roosevelt Hot Spring and to the south at Minersville (Dotson's spring, described under the next heading) suggests that this may formerly have been a hot spring. The suggestion is strengthened by the presence of the large amount of silica constituting the mound. Silica is being deposited at the present time by the hot waters of the Roosevelt Spring and the Thermo springs, but apparently not by the cooler waters of the spring north of Minersville.

This spring is favorably situated for supplying the town of Minersville with drinking water. The residents of that town are now dependent on wells, the water from which is very bad, and on the river, the water from which during the summer, at least, is derived chiefly from the seepage of the lands in Beaver Basin.

The field assay of the spring water, as given in Table 6 (p. 45) shows it to contain a large amount of dissolved solids, and it would not ordinarily be considered a good drinking water. It is much better, however, than the Minersville well waters, and although it is more saline than the river water, it is from a sanitary standpoint the best supply available for the town so far as is now known.

*Dotson's spring* (sec. 7, T. 30 S., R. 9 W.).—R. W. Dotson's spring is located in the bank of Beaver River about a mile east of Minersville. The water issues at the rate of 57 gallons per minute from an opening on the fault at the western edge of the massive limestone of the Mineral Mountains. No use is now made of the spring except for bathing, a small tank having been built for that purpose. The water has a temperature of 97° F. and is hard and saline, as shown by the field assay given in Table 6 (p. 45).

*Warm springs near Thermo.*—There is a group of warm springs about 3 miles south of Thermo, a siding on the San Pedro, Los

Angeles and Salt Lake Railroad. The springs occur in two conspicuous mounds built up from the surface of the plain by silica deposited from the spring waters. The southermost mound is about 10 feet high, 160 feet wide, and 3,000 feet long, and the northernmost one is 15 to 20 feet high, 500 feet wide, and about 5,000 feet long. Water issues from these mounds at many points, but no one of the springs yields any great volume of water. The water has a temperature of 140° F. and contains hydrogen sulphide ($H_2S$), much of which escapes as gas. The results of a laboratory analysis of this water are given in Table 9 (p. 50). The water contains also a large amount of silica in solution, most of which is deposited at the surface when the water cools and does not appear in the analysis.

*Other springs.*—Data were obtained of 23 other springs. The information is largely chemical in nature and is given in Table 6, in the section describing chemical character, on pages 42–45.

### SEEPAGE WATERS.

*Location.*—In the lower portions of Beaver Basin the surface of the ground water is at or very close to the land surface. During spring and early summer the ground-water level gradually rises, and during late summer and early autumn a considerable part of the lowlands of the valley between Beaver and Adamsville is transformed into a marsh. Many of the roads are rendered impassable and many of the fields useless for tillage or even pasturage. Nearly half of the town of Beaver was thus affected during the summer of 1906. Some of the principal streets were impassable. Water was found flowing freely from dug wells and from cellars, in some cases making houses uninhabitable. The area rendered swampy within the city is shown in fig. 3 (p. 48).

The lowlands in the vicinity of Milford and to the north, especially in Beaver Bottoms, are similarly affected, although on account of the large area of lowlands and the limited water supply swampy conditions are not so serious in the Milford region.

*Volume.*—The volume of return water is known to be very large in comparison with the flow of the streams, but no measurements are available at the present time. Some conception of the volume, however, may be obtained from the fact that 2,000 acres of the cultivated land of the valley are irrigated wholly by seepage waters. Besides this a large proportion of the seepage finds its way directly into the river and can not be measured separate from the stream flow. The chemical character of the seepage waters is shown in Table 5 (p. 43).

## DEEP WELLS.

### CLASSIFICATION.

The wells of Beaver Valley may be conveniently described in two divisions: (*a*) the bored wells, including both flowing and nonflowing wells, and (*b*) the shallow or dug wells. For the purpose of easy reference it will be convenient also to subdivide these by districts, each district being named from the town that it surrounds, except in the case of the railroad wells, which for convenience are described as being in the Milford district, although some are far from the town of Milford.

The following descriptions of the more important deeps wells are arranged in order from Beaver westward through Greenville, Adamsville, Minersville, and Milford including Beaver Bottoms.

### BEAVER DISTRICT.

*Barton well.*—J. H. Barton has a 3-inch bored well in Beaver. It is 66 feet deep and yields an ample supply of water. Saturated sands and gravels extend more or less continuously from top to bottom. The clay partings are apparently not continuous for any great distance, as the water is under no pressure. The driller's record is as follows:

*Record of J. H. Barton's well, Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 1 | 1 |
| Gravel | 25 | 26 |
| Clay | 3 | 29 |
| Gravel | 12 | 41 |
| Clay | 4 | 45 |
| Gravel | 21 | 66 |

*Cemetery well.*—There is a 2-inch drilled well at the Beaver cemetery, 180 feet deep. A gravel stratum which has water under considerable pressure, although not sufficient to produce a surface flow, was encountered at a depth of 170 feet.

*Record of Beaver cemetery well.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 1 | 1 |
| Gravel | 3 | 4 |
| Clay | 7 | 11 |
| Sand, gravel, and clay | 169 | 180 |

*Mumford well* (sec. 28, T. 29 S., R. 7 W.).—George Mumford has a 2-inch bored well, 200 feet deep, located south of Beaver. The well is not now in use, but is of interest especially in showing the character of the Beaver Lake beds and for the reason that an oil stratum was penetrated at a depth of 140 feet. The evidences of oil were not sufficient, however, to indicate the presence of any large quantity.

*Record of George Mumford's well, near Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 30 | 30 |
| Sand | 16 | 46 |
| Clay | 15 | 61 |
| Sand | 16 | 77 |
| Gravel and bowlders | 35 | 112 |
| Clay | 28 | 140 |
| Gravel | 35 | 175 |
| Sand | 25 | 200 |

*Nower well* (sec. 27, T. 29 S, R. 7 W.).—J. A. Nower has a 3-inch bored well, 213 feet deep, located near the point of the mesa south of Beaver. The water rises to a level 17 feet below the surface and has a temperature of 54° F.

*Record of J. A. Nower's well, near Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 3 | 3 |
| Clay | 3 | 6 |
| Sand and gravel | 79 | 85 |
| Clay | 5 | 90 |
| Alternating layers of sand and clay | 123 | 213 |

*Shepherd well* (sec. 20, T. 29 S., R. 7 W.).—Warren Shepherd has a 4-inch bored well, 300 feet deep, located about a mile west of Beaver, in which the water stands 2 feet below the surface of the ground. It is noteworthy that in boring this well black volcanic rock, probably basalt, was penetrated, indicating that the Beaver Lake beds, like the Lake Bonneville beds, contain sheets of basalt within the sands and gravels.

*Record of Warren Shepherd's well, west of Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 4 | 4 |
| Gravel | 2 | 6 |
| Clay | 6 | 12 |
| Sand and gravel | 31 | 43 |
| Sand and gravel alternating with black volcanic rock | 257 | 300 |

*Wolfenden & Murdock's well* (sec. 22, T. 29 S., R. 7 W.).—This well is located at the grist mill about a mile east of Beaver and is 60 feet deep. It does not reach beyond the influence of the surface changes described under the heading of shallow wells (p. 37), as do many of the deeper wells of the Beaver region, the water level being about 40 feet lower in February than in July.

*Record of Wolfenden & Murdock's well, east of Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 2 | 2 |
| Gravel | 28 | 30 |
| Clay | 2 | 32 |
| Sand and gravel | 10 | 42 |
| Clay | 10 | 52 |
| Sand | 8 | 60 |

*Other Beaver wells.*—Other deep wells were found in the Beaver district, but little was learned of them further than the meager information contained in Table 3 (p. 35).

GREENVILLE DISTRICT.

*Greenville school well* (sec. 25, T. 29 S., R. 8 W.).—This is a 3-inch bored well located in the town of Greenville. It is 244 feet deep and encountered water under pressure at 180 and 244 feet. The surface flow is about 11 gallons per minute and the quality good.

*Record of Greenville school well.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 2 | 2 |
| Gravel (water-bearing) | 178 | 180 |
| Clay | 61 | 241 |
| Sand (water-bearing) | 3 | 244 |

*Other Greenville wells.*—Several flowing wells have been bored in the vicinity of Greenville, but few definite records of the rocks penetrated are available and little information was obtained other than that given in Table 3 (p. 35).

ADAMSVILLE DISTRICT.

*Griffith well* (sec. 30, T. 29 S., R. 8 W.).—J. M. Griffith has three bored wells near the town of Adamsville. One is a 3-inch well 30 feet deep and flows 4 gallons per minute, another is a 2-inch well 100 feet deep and flows 3 gallons per minute, and the third is a 3-inch well 475

feet deep, which, on account of its location on ground higher than the others, does not flow. The driller's record of the third well is given below.

The artesian conditions of Beaver Basin are well illustrated at this point. Wells located in the lowest ground, whether deep or shallow, yield flowing water. Wells located on ground a few feet higher, although they penetrate much deeper beds—475 feet in this case—do not yield flowing water. The wells in the low ground flow apparently not because of pressure caused by an impervious layer overlying a water-bearing stratum, but because these wells afford places of comparatively easy escape for water which would eventually reach the surface by natural means but which is somewhat retarded on account of the friction within the beds through which it passes.

*Record of J. M. Griffith's well No. 3, near Adamsville.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Gravel | 14 | 14 |
| Clay | 14 | 29 |
| Gravel (water-bearing) | 32 | 60 |
| Clay | 47 | 107 |
| Gravel (water-bearing) | 68 | 175 |
| Clay | 300 | 475 |

*Parkinson well* (sec. 28, T. 29 S., R. 8 W.).—Earl Parkinson has a 3-inch bored well, 385 feet deep, about 2 miles east of Adamsville. This well differs from most of the wells in the vicinity of Adamsville in that it does not flow, the water standing 13 feet below the surface. The material penetrated also differs notably from that in the other deep wells, being mainly fine sand and clay.

*Record of Earl Parkinson's well, 2 miles east of Adamsville.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil and gravel | 27 | 27 |
| Sand and clay | 358 | 385 |

*Other Adamsville wells.*—Several other wells have been put down in the Adamsville district, but little information was obtained other than that contained in Table 3 (pp. 35–37).

MINERSVILLE DISTRICT.

*Baker & Walker's well* (sec. 8 (?), T. 30 S., R. 10 W.).—This well is located about 5 miles west of Minersville. It is a 3-inch bored well 223 feet deep. Water-bearing gravel was encountered at a depth of 185 feet, but the water is not under pressure.

*Record of Baker & Walker's well, 5 miles west of Minersville.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Clay soil | 10 | 10 |
| Gravel | 165 | 175 |
| Clay | 10 | 185 |
| Gravel (water-bearing) | 5 | 190 |
| Clay | 33 | 223 |

*Goodson well* (sec. 8, T. 30 S., R. 10 W.).—E. J. Goodson has a 3-inch bored well, 124 feet deep, about 6 miles west of Minersville. Water was found from 96 feet downward, but is under no pressure. A well belonging to Henry Baker, located about 2 miles southwest of Mr. Goodson's well, is 210 feet deep, with water under little pressure at 180 feet.

*Record of E. J. Goodson's well, 6 miles west of Minersville.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 6 | 6 |
| Gravel | 84 | 90 |
| Clay | 6 | 96 |
| Gravel (water-bearing) | 10 | 106 |
| Sand and clay | 18 | 124 |

*Van Patten well.*—F. A. Van Patten has a 3-inch drilled well, 125 feet deep, at Minersville. Water was not found below a depth of 95 feet, and the casing was drawn back to that depth.

*Record of F. A. Van Patten's well, Minersville.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 1 | 1 |
| Gravel | 24 | 25 |
| Alternating layers of clay, sand, and gravel (water-bearing) | 90 | 115 |
| Clay | 10 | 125 |

*Other Minersville wells.*—There are several bored wells in Minersville, but little of interest was learned of them. The scanty information is to be found in Table 3 (p. 36).

MILFORD DISTRICT.

*Milford town well.*—The town of Milford is supplied with water from a bored well 425 feet deep, located at the foot of the gravel bench which occurs at the west edge of the town. The upper 300 feet of the well is cased with 6-inch pipe, from the lower end of which a 4-inch pipe extends to the bottom of the well, the water

coming entirely from a depth of 425 feet. The water has a pressure of 6 pounds per square inch at the surface, flows 30 gallons per minute, and has a temperature of 72° F.

The natural flow of the well is not sufficient to supply the town, and the water is pumped by a 10-horsepower gasoline engine to a cement reservoir, 28 by 72 feet and 6½ feet deep, located on the gravel bench 60 feet above the town. The pump ordinarily discharges 156 gallons per minute, and the well readily yields this amount. No determination has been made of the maximum possible yield of the well, but it would apparently supply much more than 156 gallons per minute.

The surface water at Milford is brackish and for this reason is cased out of the town well. The analysis in Table 9 (p. 50) shows that the water from the depth of 425 feet is very good for domestic purposes.

*Lewis well.*—A. B. Lewis has a bored well in the town of Milford that is cased to a depth of 450 feet with 4-inch pipe, inside of which a 2-inch pipe extends to a depth of 750 feet. From the outer pipe water flows at the rate of 37 gallons per minute and has a temperature of 80° F. Water also flows from the inner pipe at the rate of 2 gallons per minute, and since it is surrounded by the water of the outer pipe it issues with the same temperature, 80° F. The water from the 750-foot level differs from that at 450 feet in containing much more mineral matter in solution, as shown in Table 3 (p. 36), and also in containing hydrogen sulphide ($H_2S$).

*Record of A. B. Lewis's well, Milford.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 12 | 12 |
| Gravel | 48 | 60 |
| Clay and sand in alternating layers | 390 | 450 |
| Clay | 80 | 530 |
| Quicksand | 5 | 535 |
| Clay | 215 | 750 |
| Sand | | (?) |

*Winberg well.*—A. W. Winberg has a 2-inch bored well at the steam laundry in Milford. It is 326 feet deep and penetrates water-bearing strata at depths of 260, 285, 310, and 326 feet, all four beds yielding flowing water. The pressure at the mouth of the well is 6 pounds per square inch and the flow 9 gallons per minute. The quality of the water is excellent and is practically the same as that from the town well.

*Record of A. W. Winberg's well, Milford.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Clay | 16 | 16 |
| Gravel (water-bearing) | 44 | 60 |
| Alternating beds of clay, sand, and gravel (water-bearing) | 266 | 326 |

*Railroad well.*—The San Pedro, Los Angeles and Salt Lake Railroad has three flowing wells at Milford. Two of them are 2-inch wells about 400 feet deep, each discharging 18 gallons per minute; the third, a 12-inch well, 310 feet deep, located near the railroad station, ordinarily flows 30 gallons per minute, the pressure at the surface being about 6 pounds per square inch. Ground water here occurs at a depth of 8 feet and artesian flows at 170 and 310 feet. The flow is not sufficient to supply enough water for railroad use at this station, and water is pumped from the 12-inch well at the rate of 270 gallons per minute. The driller's record of this well follows, and an analysis of the water is given in Table 10 (p. 51).

*Record of the San Pedro, Los Angeles and Salt Lake Railroad 12-inch well, Milford.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 4 | 4 |
| Sand | 6 | 10 |
| Blue clay | 22 | 32 |
| Sand | 33 | 65 |
| Blue clay | 10 | 75 |
| Sand and gravel | 15 | 90 |
| Blue clay | 25 | 115 |
| Hardpan | 4 | 119 |
| Quicksand | 35 | 154 |
| Blue clay | 15 | 169 |
| Sand (artesian flow) | 5 | 174 |
| Red clay | 81 | 255 |
| Quicksand | 10 | 265 |
| Sand | 5 | 270 |
| Clay | 8 | 278 |
| Sand | 10 | 288 |
| Yellow clay | 17 | 305 |
| Cemented gravel (artesian flow) | 5 | 310 |

*Milwaukee Leasing Company's well* (sec. 31(?), T. 28 S., R. 11 W.).—This well is located about 8 miles southwest of Milford, at the Milwaukee Leasing Company's stamp mill. It was originally a 6-inch drilled well, 90 feet deep, with water at a depth of 45 feet. Later an open shaft was dug to water level. The water is pumped for use in the stamp mill in sufficient quantity to supply the 20 stamps operated.

East and south of the mill and on lower ground water is found under considerable pressure. Large so-called artesian springs are reported there, and one well drilled several years ago still flows to some extent.

*Majestic Copper Mining and Smelting Company's wells.*—There are four flowing wells at the smelter 2 miles south of Milford, 95, 340, 465, and 470 feet deep. The smelter is not now in operation, and little information regarding the wells could be obtained. The flow is slight, owing probably to the location of the wells on a bench several feet above the valley bottom.

*Wells in Beaver Bottoms.*—J. C. White reports 20 flowing wells in Beaver Bottoms, many of them bored by himself. Water having pressure sufficient to produce a slight surface flow from wells located on the lowest ground occurs in beds of sand and gravel at depths of 180 to 200 feet below the surface. The wells are all very small, the casing varying from 1 to 2 inches in diameter, and the flow is only 1 to 3 gallons per minute.

An attempt was made several years ago to find other water-bearing strata, and a well was sunk on the Ryan ranch near Read (formerly Smith's station) to a depth of 860 feet. The sediment encountered was all very fine. Some sand was found with the clay to a depth of 300 feet, but below this the material penetrated was wholly clay.

The waters of Beaver Bottoms are strongly charged with saline matter, the artesian waters more so than the surface waters. In this respect the relations at Milford, 10 miles to the south, are reversed. The surface waters of Milford and of Beaver Bottoms probably do not differ greatly in salinity, but the artesian waters of the latter place are so strongly saline that the surface waters seem good by comparison. The field assays of water from James Forgie's dug well, 18 feet deep, and artesian well, 215 feet deep, are shown in Table 3 (p. 36).

A laboratory analysis of water from J. C. White's artesian well, 185 feet deep, located in Beaver Bottoms about 2 miles east of James Forgie's well, is given in Table 9 (p. 50).

### RAILROAD WELLS OUTSIDE OF BEAVER VALLEY.

No great thickness of the Lake Bonneville beds is exposed at the surface in the Escalante Desert, and the character of the sediments is best shown by well records. There are few carefully kept records available within the limits of the area described in this paper, and for this reason it is thought advisable to include some obtained from places outside of Beaver County, but within the limits of the Escalante Desert, and therefore having a direct bearing on the discussion of underground waters in Beaver Valley. Several wells have been bored for the San Pedro, Los Angeles and Salt Lake Railroad in the Escalante Desert between Beryl and Lynn, the locations of which are shown in fig. 1 (p. 7). J. A. Shanahan, one of the officials of the railroad, has very kindly furnished the following information for use in this report.

*Beryl.*—The railroad has a 13-inch bored well at Beryl, 208 feet deep. Water was encountered at depths of 23, 180, and 203 feet and rises within 19 feet of the surface. During a pumping test of twenty-four hours the well is said to have yielded 183 gallons of water per minute.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad well at Beryl.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 8 | 8 |
| Clay and gravel | 8 | 16 |
| Gravel (water-bearing) | 7 | 23 |
| Gravel and clay | 15 | 38 |
| Clay | 80 | 118 |
| Clay and gravel | 57 | 175 |
| Gravel (water-bearing) | 5 | 180 |
| Clay | 20 | 200 |
| Sand (water-bearing) | 3 | 203 |
| Clay | 5 | 208 |

*Lund.*—The well at Lund, completed in 1903, is 585 feet deep. Flowing water was encountered at five horizons, as shown by the following log. The well is cased with 12-inch pipe at the top, but this is reduced below to 10, 8, and finally to 6 inches. The well flows 20 gallons per minute and when pumped yields 100 gallons per minute, with a temporary depression of the water surface of less than 20 feet.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad well at Lund.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand | 2 | 2 |
| Clay | 4 | 6 |
| Gravel (small flow) | 6 | 12 |
| Coarse gravel | 4 | 16 |
| Hardpan and clay | 49 | 65 |
| Quicksand | 4 | 69 |
| Blue clay | 80 | 149 |
| Sand | 4 | 153 |
| Red clay | 12 | 165 |
| Blue clay | 159 | 324 |
| Red rock | 6 | 330 |
| Blue clay | 70 | 400 |
| Quicksand | 20 | 420 |
| Green shale rock | 10 | 430 |
| Clay and sand | 10 | 440 |
| Sand (small flow) | 3 | 443 |
| Blue clay | 11 | 454 |
| Clay and sand | 8 | 462 |
| Sand (large flow) | 13 | 475 |
| Clay | 3 | 478 |
| Sand | 6 | 484 |
| Red clay | 2 | 486 |
| Very fine sand | 8 | 494 |
| Red clay | 10 | 504 |
| Dark clay | 4 | 508 |
| Blue clay | 14 | 522 |
| Very fine sand | 3 | 525 |
| Blue clay | 2 | 527 |
| Fine sand (small flow) | 3 | 530 |
| Brown clay | 19 | 549 |
| Sand | 1 | 550 |
| Brown clay | 23 | 573 |
| Coarse sand | 10 | 583 |
| Coarse gravel (large flow) | 2 | 585 |
| Blue clay | | |

*Thermo.*—The well at Thermo, completed in 1905, is 401 feet deep and encountered water at several horizons. It is cased with 12-inch pipe to a depth of 337 feet. During a pumping test the well supplied 100 gallons of water per minute, with a temporary lowering of the water surface of less than 16 feet.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad well at Thermo.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 5 | 5 |
| Fine gravel | 5 | 10 |
| Red sand | 3 | 13 |
| White clay | 25 | 38 |
| Fine gravel (water-bearing) | 3 | 41 |
| White clay | 54 | 95 |
| Red clay | 45 | 140 |
| Quicksand | 27 | 167 |
| Red clay | 13 | 180 |
| Sand and clay | 25 | 205 |
| Blue clay | 20 | 225 |
| Sand | 10 | 235 |
| Clay | 9 | 244 |
| Clay and gravel | 31 | 275 |
| Clay and sand | 41 | 316 |
| Clay and gravel | 12 | 328 |
| Sand | 13 | 341 |
| Clay and gravel (water-bearing) | 60 | 401 |

*Neels.*—The well at Neels, completed in 1906, is 1,998 feet deep. Water was encountered at several horizons, as indicated in the following log, but nowhere under pressure enough to force it to the surface. All of the water is said to have been hot, and steam escaped freely from the well during the process of boring. The water at every horizon was found to be of poor quality, although a large quantity was obtained, 260 to 300 gallons per minute being pumped during a test lasting continuously for twenty-four days. This test was made with the hope that continuous pumping would clear the well and improve the quality of the water, but no improvement was shown. An attempt was then made to sink the well deeper into the granite, but the rock was found to be fractured and the crevices deflected the drill laterally and otherwise proved so bothersome that the well was abandoned.

A slight amount of oil was found at several horizons in this well, and gas under great pressure was encountered at a depth of 1,802 feet.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad Well at Neels.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Surface soil | 4 | 4 |
| Sedimentary (alkali) | 5 | 9 |
| Fire clay | 10 | 19 |
| Water-bearing quicksand | 9 | 28 |
| Shale and soapstone | 21 | 79 |
| Rock (sedimentary) | 6 | 85 |
| Water-bearing quicksand | 3 | 88 |
| Soapstone | 11 | 99 |
| Soapstone with fossil bowlders | 39 | 138 |
| Water-bearing quicksand | 4 | 142 |
| Fire clay | 12 | 154 |
| Blue waxy clay | 34 | 188 |
| Gray shale and clay mixed | 7 | 195 |
| Gray waxy clay | 36 | 231 |
| Lava rock | 12 | 243 |
| Blue waxy clay | 12 | 255 |
| Sedimentary sandstone | 6 | 261 |
| Blue waxy clay | 25 | 286 |
| Water-bearing quicksand | 6 | 292 |
| Blue waxy clay | 28 | 320 |
| Water-bearing quicksand | 7 | 327 |
| Sedimentary sandstone | 10 | 337 |
| Yellow clay | 16 | 353 |
| Water-bearing quicksand | 5 | 358 |
| Yellow clay | 27 | 385 |
| Blue waxy clay | 110 | 495 |
| Yellow clay | 15 | 510 |
| Sedimentary sandstone | 24 | 534 |
| Blue waxy clay | 17 | 551 |
| Soapstone | 50 | 601 |
| Blue waxy clay | 11 | 612 |
| Silt | 8 | 620 |
| Water-bearing quicksand | 3 | 623 |
| Yellow clay | 53 | 676 |
| Sedimentary sandstone | 12 | 688 |
| Yellow clay | 34 | 722 |
| Blue waxy clay | 117 | 839 |
| Yellow clay | 9 | 848 |
| Blue waxy clay | 210 | 1,058 |
| Blue shale (sand mixed) | 18 | 1,076 |
| Blue waxy clay | 13 | 1,089 |
| Blue shale | 45 | 1,134 |
| Blue shale (sand mixed); yielded hot water | 71 | 1,205 |
| Red shale | 12 | 1,217 |
| Blue shale | 70 | 1,287 |
| Red shale | 24 | 1,311 |
| Blue shale | 28 | 1,339 |
| Red "keel" stone | 6 | 1,345 |
| Water, sand, gravel, and bowlders | 70 | 1,415 |
| Sedimentary sandstone, brown | 35 | 1,450 |
| Red sandstone | 95 | 1,545 |
| Red shale, burned | 35 | 1,580 |
| Trap rock, dark brown | 36 | 1,616 |
| Red shale, burned | 56 | 1,672 |
| Lava rock with calcite crystals | 14 | 1,686 |
| Red sandstone | 68 | 1,754 |
| Red clay, sticky | 48 | 1,802 |
| Volcanic deposit, ash, and bowlders; gas under pressure sufficient to raise 6,200 pounds of tools 400 feet | 105 | 1,907 |
| Bowlders, cemented | 6 | 1,913 |
| Cavity | 9 | 1,922 |
| Bowlders | 22 | 1,944 |
| Cavity | 6 | 1,950 |
| Granite with crevices and gas | 48 | 1,998 |

*Oasis.*—The well at Oasis, completed in 1905, is 656 feet deep and is cased with 12-inch pipe to a depth of 73 feet, below which 10-inch casing extends to the bottom of the well. Water under pressure sufficient to cause it to flow at the surface was encountered at ten different horizons, and there seems to be an unusual quantity of water present. During a pumping test the well supplied 200 gallons per minute, with a temporary depression of the water surface of only

3 feet. At no horizon, however, was the water found to be suitable for boiler purposes. A drinking water of good quality, prized for its mineral qualities, occurs at a depth of 350 feet, and the casing was shot off, so that the present flow of 30 gallons per minute comes entirely from this depth. The drinking water used on the dining cars and in the offices of the railroad is supplied by this well.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad well at Oasis.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 8 | 8 |
| Sand | 3 | 11 |
| Blue clay | 49 | 50 |
| Sand | 10 | 60 |
| Lime and shells | 20 | 80 |
| Quicksand | 45 | 125 |
| Blue clay | 40 | 165 |
| Sand | 5 | 170 |
| Blue clay | 20 | 190 |
| Red clay | 45 | 335 |
| Sand | 15 | 350 |
| Blue clay | 20 | 370 |
| Red clay | 25 | 395 |
| Sand | 13 | 408 |
| Sandstone | 4 | 412 |
| Blue clay | 68 | 480 |
| Sand | 11 | 491 |
| Red clay | 9 | 500 |
| Blue clay | 27 | 527 |
| Quicksand | 3 | 530 |
| Clay and sand | 29 | 559 |
| Black sand | 3 | 562 |
| Clay and gravel | 13 | 575 |
| Clay | 23 | 598 |
| Cemented gravel | 12 | 610 |
| Soft sandstone | 7 | 617 |
| Clay | 6 | 623 |
| Rock | 2 | 625 |
| Clay | 15 | 640 |
| White clay | 16 | 656 |

*Lynn.*—The well at Lynn, completed in 1905, is 235 feet deep and is cased with 12-inch pipe to a depth of 225 feet. The water does not flow at the surface, but has been pumped at the rate of 90 gallons per minute.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad well at Lynn.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Clay | 8 | 8 |
| Gravel | 10 | 18 |
| Sand | 12 | 30 |
| Sand and gravel | 10 | 40 |
| Sand | 20 | 60 |
| Blue clay | 95 | 155 |
| Blue sandy clay, water bearing | 60 | 215 |
| Sand | 10 | 225 |
| Coarse gravel, water bearing | 10 | 235 |

STATISTICS OF DEEP WELLS.

The following table comprises such information in regard to the deep wells of Beaver Valley as can be conveniently presented in this form:

TABLE 3.—*Statistics of deep wells in Beaver Valley.*

[Chemical determinations in parts per million. Wells marked with asterisk not on Pl. I.]

| No. on Pl. I. | District and owner. | Location. | Character of well. | Depth. | Depth to water horizons. | Flow per minute. | Temperature. | Iron (Fe). | Total alkalinity as $CaCO_3$. | Alkaline carbonate. | Sulphate radicle ($SO_4$). | Total hardness ($CaCO_3$). | Chlorine (Cl). | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BEAVER DISTRICT. | | | *Feet.* | *Feet.* | *Gals.* | ° *F.* | | | | | | | |
| 1 | Barton, J. H | Beaver | Nonflowing | 66 | 29<br>45 | | 52 | 0 | 243 | 0 | <35 | | 60 | |
| 2 | Beaver cemetery | do | do | 180 | 170 | | | | | | | | | |
| 3 | Hurst, Wm | do | do | | | | | 1 | 255 | 0 | 35 | | 28 | |
| 4 | McGregor, D. A | do | do | 60 | | | 55 | 0 | 142 | 0 | Tr. | | 120 | |
| 5 | Murdock | do | | 40 | | | | 0 | 203 | 0 | Tr. | | 58 | Low in February, high in July; variation, 24 feet. |
| 6 | Mumford, George | Sec. 28, T. 29 S., R. 7 W | Nonflowing | 200 | | | | | | | | | | Well not in use. |
| 7 | Nower, J. A | do | do | 213 | | | 54 | | | | | | | |
| 8 | Shepherd, Warren | Sec. 20, T. 29 S., R. 7 W | do | 300 | | | | | | | | | | |
| *9 | Tolton, J. F | Beaver | do | 62 | 45<br>61 | | 51 | 0 | 203 | 0 | 0 | | 60 | |
| | GREENVILLE DISTRICT. | | | | | | | | | | | | | |
| 10 | Barton, S. R | Sec. 36, T. 29 S., R. 8 W | Flowing | 314 | 200<br>314 | 7 | 74 | 0 | 142 | 0 | Tr. | 56 | 20 | Low in February, high in July. |
| 11 | Blackner, O | Sec. 35, T. 29 S., R. 8 W | do | 23 | | | | 0 | 364 | 0 | 35 | | 30 | |
| 12 | Edwards, Wm | Sec. 34, T. 29 S., R. 8 W | Nonflowing | 95 | 36<br>44<br>95 | | | Tr. | 446 | 0 | <35 | | 106 | |
| 13 | Farnsworth, G. T | Sec. 35, T. 29 S., R. 8 W | do | 35 | 5 | | | 0 | 405 | 0 | <35 | | 81 | Low in February, high in June. |
| 14 | Greenville school | Greenville | Flowing | 244 | 180<br>244 | 11 | 68 | 0 | 242 | 0 | Tr. | 90 | 10 | |
| 15 | Murdock, J. M | Sec. 24, T. 29 S., R. 8 W | do | 163 | | 15 | 55 | 0 | 132 | 0 | Tr. | 75 | 15 | |
| | ADAMSVILLE DISTRICT. | | | | | | | | | | | | | |
| 16 | Griffiths, J. M | Sec. 30, T. 29 S., R. 8 W | Flowing | 100 | | 3 | 52 | 0 | 162 | 0 | <35 | 65 | 50 | |
| 17 | do | Sec. 19, T. 29 S., R. 8 W | do | 30 | | 4 | 51 | Tr. | 240 | 0 | <35 | | 60 | |
| *18 | do | Sec. 30, T. 29 S., R. 8 W | Nonflowing | 475 | 8<br>37<br>100 | | | | | | | | | |

TABLE 3.—*Statistics of deep wells in Beaver Valley*—Continued.

| No. on Pl. I. | District and owner. | Location. | Character of well. | Depth. | Depth to water horizons. | Flow per minute. | Temperature. | Iron (Fe). | Total alkalinity as $CaCO_3$ | Alkaline carbonate. | Sulphate radicle ($SO_4$). | Total hardness ($CaCO_3$). | Chlorine (Cl). | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ADAMSVILLE DISTRICT—Con. | | | *Feet.* | *Feet.* | *Gals.* | °*F.* | | | | | | | |
| 19 | Grimshaw, F. T | Sec. 30, T. 29 S., R. 8 W | Flowing | | | | | | | | | | | |
| *20 | Gunn, Fred T | Sec. 30, T. 29 S., R. 8 W | do | | | 60 | | | | | | | | |
| 21 | Johnson, Sam'l | Sec. 30, T. 29 S., R. 8 W | Nonflowing | 32 | 14<br>32 | | | 1 | 364 | 0 | <35 | 194 | 80 | |
| 22 | Joseph, J. H | Sec. 30, T. 29 S., R. 8 W | do | 50 | | | 55 | | | | | | | |
| 23 | Parkinson, E | Sec. 28, T. 29 S., R. 8 W | do | 385 | | | 53 | | | | | | | |
| | MINERSVILLE DISTRICT. | | | | | | | | | | | | | |
| 24 | Baker, H. F | Minersville | Nonflowing | | | | 56 | 0 | 324 | 0 | 113 | | 101 | |
| 25 | Baker, Henry | Sec. 16, T. 30 S., R. 10 W | do | 210 | 180 | | | | | | | | | |
| 26 | Baker & Walker | Sec. 8, T. 30 S., R. 10 W | do | 223 | 185 | | | | | | | | | |
| *27 | Dotson, R. W | Sec. —, T. 30 S., R. 10 W | do | 53 | | | | 1 | 447 | 0 | 168 | 230 | 131 | |
| *28 | do | Minersville | do | | | | | Tr. | 360 | 0 | 35 | 272 | 80 | |
| 29 | Goodson, E. J | Sec. 7, T. 30 S., R. 10 W | do | 124 | 93 | | | | | | | | | |
| *30 | Hollingshead, S. B | Minersville | do | 100 | | | | Tr. | 223 | 0 | 328 | 550 | 808 | |
| *31 | Kelsey, W. M | do | do | 56 | 25<br>36<br>58 | | 56 | 12 | 295 | 0 | 191 | | 446 | |
| *32 | Marshall, Geo | do | do | 38 | | | 55 | 0 | 358 | 0 | 222 | 689 | 242 | |
| *33 | Murdock, L. E | do | do | 42 | | | | 0 | 324 | Tr. | 35 | | 40 | |
| *34 | Van Patten, F. A | do | do | 125 | 95 | | 56 | 0 | 326 | 0 | 56 | | 95 | |
| 35 | Walker, H. A | Sec 15, T. 30 S., R. 10 W | do | 180 | 180 | | 55 | 0 | 370 | 0 | 71 | | 161 | |
| | MILFORD DISTRICT. | | | | | | | | | | | | | |
| 36 | Forgie, John | Milford | Flowing | 336 | 150<br>315 | 25 | 65 | 0 | 140 | Tr. | 0 | | 13 | Flow ceases when railroad well 200 yards away is pumped. |
| 37 | do | Sec. 18, T. 28 S., R. 10 W | do | 357 | | 25 | 78 | 0 | 141 | 0 | Tr. | | 14 | |
| 38 | do | Sec. 8, T. 28 S., R. 10 W | do | 381 | 345 | 13 | 65 | | | | | | | |
| 39 | Forgie, James | Sec. 7, T. 26 S., R. 10 W | do | 215 | | | | 4 | 466 | 0 | 36 | | 1,752 | |
| *40 | do | Sec. 7, T. 26 S., R. 10 W | Dug | 18 | | | | 0 | 648 | 283 | 0 | | 662 | |
| *41 | Grace Bros | Milford | Nonflowing | 48 | | | 60 | 0 | 162 | 0 | 35 | 216 | 148 | |
| 42 | Harrington, Mrs | do | do | 55 | 43 | | | | | | | | | |
| 43 | Holderman & Sons | Sec. 18, T. 28 S., R. 10 W | Flowing | 420 | | | | | | | | | | |
| *44–45 | Lewis, A. B | Milford | do | 750 | 300<br>750 | 37<br>2 | 80<br>80 | 0 | 145<br>283 | 0<br>0 | 0<br>0 | | 17<br>35 | Sulphur water from bottom. |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *46 | McCauley, J. D. | do | Flowing | 280 | | 7 | 68 | | | | | | | | Flow has decreased from 17 gallons per minute. |
| *47 | McKean, P. B. | do | Nonflowing | 60 | | | 59 | Tr. | 152 | 0 | 38 | | 181 | | |
| *48 | Milford town | do | Flowing | 425 | | 30 | 72 | 0 | 162 | 0 | Tr. | 69 | 13 | | 117 gallons per minute pumped. |
| *49 | Milford school | do | Dug | 35 | | | | | | | | | | | |
| *50 | Milwaukee Leasing Company | T. 28 S., R. 11 W. | Nonflowing | 90 | 45 | | | | | | | | | | Supplies a 20-stamp mill. |
| *51 | Mowre, A. W. | Milford | do | 45 | | | | 0 | 162 | 0 | 41 | | 424 | | |
| 52 | Murdock, J. M. | Sec. 18, T. 26 S., R. 10 W. | Flowing | 180 | | | | 0 | 263 | 0 | 0 | | 836 | | |
| 53 | Ryan ranch | Sec. 5, T. 26 S., R. 10 W. | do | 860 | | | | | | | | | | | Not used. |
| 54 | San Pedro, Los Angeles and Salt Lake R. R.[a] | Milford | do | 310 | 170<br>310 | 30 | 71 | 0 | 160 | 0 | Tr. | 49 | 12 | | 270 gallons per minute pumped. |
| *55 | do | do | do | 400 | | 18 | | 0 | 142 | 0 | Tr. | | 15 | | |
| *56 | do | Beryl | Nonflowing | 208 | | | | | | | | | | | 183 gallons per minute pumped. |
| *57 | do | Lund | Flowing | 585 | | 20 | | | | | | | | | 100 gallons per minute pumped. |
| 58 | do | Thermo | Nonflowing | 401 | | | | | | | | | | | Do. |
| *59 | do | Neels | do | 1998 | | | | | | | | | | | 300 gallons per minute pumped. |
| *60 | do | Oasis | Flowing | 656 | | 30 | | | | | | | | | 200 gallons per minute pumped. |
| *61 | do | Lynn | Nonflowing | 235 | | | | | | | | | | | 90 gallons per minute pumped. |
| 62 | Tanner, E. | Sec. 5, T. 28 S., R. 10 W. | Flowing | 286 | | 8 | 71 | 0 | 101 | 0 | <35 | | 38 | | |
| *63 | do | Sec. 5, T. 28 S., R. 10 W. | do | 370 | | 8 | 67 | | | | | | | | |
| 64 | Whitaker, Arthur | Sec. 32, T. 27 S., R. 10 W. | do | 403 | | 18 | | | | | | | | | Many water-bearing strata. |
| *65 | Winberg, A. W. | Milford | do | 326 | 260<br>285<br>310<br>326 | 9 | 68 | 0 | 130 | Tr. | <35 | | 24 | | Pressure 7 pounds per square inch. |
| 66 | White, J. C. | Sec. 17, T. 26 S., R. 10 W. | do | 185 | | | | 0 | 666 | 383 | 0 | | 1787 | | |

[a] For exact analyses of water from railroad wells see Table 10 (p. 51).

## SHALLOW WELLS.

*Tabulated data.*—There is little to be said of individual shallow wells and the available information is probably best presented in tabular form. For convenience of reference these wells are arranged like the deep wells, by districts, and in order to avoid duplication the chemical analyses described on page 46 are included in the table.

TABLE 4.—*Statistics of shallow wells in Beaver Valley.*

[Chemical determinations in parts per million.]

| District and owner. | Location. | Depth. | Fluctuation of water surface. | Iron (Fe). | Total alkalinity at $CaCO_3$. | Alkaline carbonates. | Sulphate radicle ($SO_4$). | Chlorine (Cl.). | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| BEAVER DISTRICT. | | *Feet.* | *Feet.* | | | | | | |
| Ash, Joseph | Beaver | 24 | 16 | 0 | 223 | 0 | Tr. | 35 | Low in February, high in July. |
| Atkins, Alice | do | | | 0 | 281 | 0 | <35 | 70 | |
| Baldwin, M. D | do | | | 0 | 255 | 0 | 0 | 24 | |
| Barrachouch, J | do | | | 2 | 253 | 0 | <35 | 50 | |
| Bastian, L. H | Sec. 21, T. 28 S., R. 7 W | 29 | 14 | 0 | 142 | 0 | <35 | 19 | Low in February, high in June. |
| Boyter, A | Beaver | 52 | 44 | | | | | | Low in February, high in July. |
| Do | Sec. 9, T. 29 S., R. 7 W | 8 | 7 | | | | | | Do. |
| Burt, William | Beaver | | | 0 | 264 | 0 | 0 | 28 | |
| Briggs, John | Sec. 2, T. 29 S., R. 7 W | 50 | | | | | | | Water only during irrigation. |
| Day, Joseph | Sec. 35, T. 28 S., R. 7 W | 14 | 10 | Tr. | 122 | 0 | <35 | 15 | Low in February, high in July. |
| Dean, Jeddy | Beaver | 22 | 19 | 0 | 223 | 0 | 0 | 20 | Do. |
| Farnsworth, R | Sec. 21, T. 28 S., R. 7 W | 23 | | Tr. | 157 | 0 | <35 | 186 | Do. |
| Farnsworth, L. E | Do | 35 | 18 | | | | | | Do. |
| Farnsworth, W. H | Beaver | | | Tr. | 233 | 0 | <35 | 198 | |
| Gale, O. W | Sec. 3, T. 29 S., R. 7 W | 30 | 22 | | | | | | Do. |
| Gale, M. H | Sec. 4, T. 29 S., R. 7 W | 42 | 15 | 0 | 207 | 0 | <35 | 30 | Do. |
| Geordy, David | Beaver | 37 | 29 | | | | | | Do. |
| Grimshaw, D | Do | 33 | 30 | 0 | 273 | 0 | Tr. | 43 | Do. |
| Goodwin, I. S | Do | | | 0 | 233 | 0 | Tr. | 51 | |
| Hanson, W. L | Sec. 28, T. 29 S., R. 7 W | 10 | 6 | 0 | 202 | 0 | 0 | 10 | Do. |
| Harris, H | Beaver | | | Tr. | 182 | 0 | <35 | 80 | |
| Harris, L. H | Do | | | Tr. | 252 | 0 | Tr. | 28 | |
| Harris, Lydia | Do | | | 0 | 283 | 0 | Tr. | 60 | |
| Huntington, Mrs. E | Do | | | 0 | 195 | 0 | Tr. | 53 | |
| Hodges, C. H | Sec. 3 T. 29 S., R. 7 W | 30 | 13 | | | | | | Do. |
| Howd, S. F | do | | | 3 | 253 | 0 | Tr. | 47 | |
| Jackson, Jos | do | | | 0 | 298 | 0 | <35 | 141 | |
| Jones, J. F | Beaver | 24 | 20 | 0 | 273 | 0 | <35 | 80 | Sample taken Aug. 24, 1906. Low in February, high in July. |
| Do | do | | | 0 | 243 | | <35 | 65 | Sample taken Aug. 2, 1906. |
| Lawrence, A. L | do | | | Tr. | 250 | 0 | <35 | 70 | |
| Manhardt, W. M | Sec. 31, T. 28 S., R. 6 W | 20 | 15 | 0 | 152 | 0 | <35 | 24 | Low in February, high in July. |
| Mansfield, E. M | do | 47 | 31 | 0 | 223 | 0 | Tr. | 25 | |
| Morgan, Edward | do | | | 0 | 234 | 0 | Tr. | 33 | |
| Muir John J | do | | | 0 | 245 | 0 | <35 | 63 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mumford, Geo | Sec. 28, T. 29 S., R. 7 W | 40 | 10 | | | | | | Low in February, high in July; water brackish. |
| Neilson, N. B | Beaver | | 42 | 0 | 253 | 0 | 0 | 49 | Low in February, high in July. |
| Okenden, C | do | | | 0 | 241 | 0 | <35 | 303 | |
| Owens, G. E | Sec. 22, T. 29 S., R. 7 W | 17 | 12 | 0 | 253 | 0 | 0 | 35 | Do. |
| Paice, Geo | Beaver | 33 | 29 | | | | | | Do. |
| Rees, Watkin | do | 25 | 22 | 0 | 243 | 0 | <35 | 46 | Do. |
| Robinson, Eliza | do | | | 2 | 223 | 0 | Tr. | 40 | |
| Smith, Seth W | do | | | 0 | 243 | 0 | 0 | 65 | |
| Stony, F. J | do | | | 0 | 304 | 0 | Tr. | 18 | |
| Swindelhurst, E. B | do | | | 0 | 242 | 0 | Tr. | 35 | |
| Thompson, Wm | do | 46 | 38 | | | | | | Low in January, high in July. |
| Twitchell, W. A | Sec. 31, T. 29 S., R. 6 W | 20 | 15 | | | | | | Variation caused wholly by irrigation. |
| Twitchell, D. F | Sec. 21, T. 28 S., R. 7 W | 15 | 4 | | | | | | Low in February, high in July; water brackish. |
| Valentine, Jos | Sec. 35, T. 28 S., R. 7 W | 12 | 4 | | | | | | |
| Wolfenden, C | Beaver | | | 0 | 235 | 0 | Tr. | 30 | |
| Whitaker, O. A | do | 44 | 3 | | | | | | Low in February, high in July. |
| Wilden, E | do | 13 | 8 | 0 | 121 | 0 | 0 | 25 | Do. |
| Woodbury, Chas | Sec. 10, T. 29 S., R. 7 W | 101 | | | | | | | Water only during irrigation season. |
| Wolfenden & Murdock | Beaver | 60 | 40 | 0 | 344 | 0 | <35 | 70 | |
| Woolsey, D. M | Sec. 35, T. 28 S., R. 7 W | 85 | | | | | | | No water. |
| GREENVILLE DISTRICT. | | | | | | | | | |
| Edwards, William | Sec. 25, T. 29 S., R. 8 W | 5 | 1 | 0 | 308 | 0 | 35 | 63 | Low in September, high in July; hardness 263. |
| Farnsworth, G. T | Sec. 35, T. 29 S., R. 8 W | 35 | 0 | 0 | 405 | 0 | <35 | 81 | |
| Murdock, John M | Sec. 24, T. 29 S., R. 8 W | 20 | 0 | | | | | | Water brackish. |
| ADAMSVILLE DISTRICT. | | | | | | | | | |
| Johnson, C | Sec. ?, T. 29 S., R. 8 W | 7 | 7 | Tr. | 496 | 0 | 35 | 141 | Low in September, high in June. |
| Jones, Cutler & Fennemore | Sec. 32, T. 29 S., R. 8 W | 49 | 20 | Tr. | 284 | 0 | Tr. | 121 | Water brackish; improves during irrigation. |
| Stewart, Lewis | Sec. 29, T. 29 S., R. 8 W | 23 | | 0 | 567 | 0 | 43 | 132 | Low in February, high in July. |
| MINERSVILLE DISTRICT. | | | | | | | | | |
| Banks, J. R | Minersville | 28 | 16 | 0 | 324 | 0 | <35 | 41 | |
| Banks, W. H | do | 21 | | 0 | 370 | 0 | 265 | 232 | Total hardness 438. |
| Burke, Lydia | do | 13 | 7 | 0 | 370 | 0 | 168 | 125 | Low in September, high in June. |
| Dotson, R. W | do | 23 | 7 | Tr. | 360 | Tr. | <35 | 80 | |
| Minersville town well | T. 30 S., R. 11 W | 80 | | 2 | 125 | 0 | 0 | 50 | |
| Walker, H. A | Minersville | 23 | 5 | 0 | 370 | 0 | 85 | 161 | |

*Water-bearing material.*—The material near the surface of the Beaver Lake beds consists mainly of coarse sand and gravel and is but slightly consolidated. Some of it is made up of sand and rounded pebbles, presumably lake sediments, deposited before Beaver basin was drained by the down cutting of the river in the canyon at Minersville, and some of it is coarse and subangular, deposited by the streams. In some places the gravels are exposed at the surface over considerable areas and in others they are covered with a thin veneer of soil. In no place observed had soil or silt accumulated to any great depth. The wells are nearly all in gravel, as illustrated in Mr. Boyter's well, a record of which is given below:

*Record of A. Boyter's well, Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 1 | 1 |
| Gravel | 24 | 25 |
| Clay | 2 | 27 |
| Gravel | 24 | 51 |
| Sand | 1 | 52 |

The abundance of unconsolidated gravel near the surface and the scarcity of surface soil are due, in part at least, to the steep grade of the streams, causing current velocities that preclude the possiblity of deposition of the finer materials. The gravels exposed at the surface allow the rain water, the stream water, and the irrigation water to sink readily into the ground and the absence of fine material from the gravel beds makes it possible for water to move rapidly through them.

Where the Beaver Lake beds are exposed to view through any considerable thickness, as in the bench south of Beaver and in similar exposures to the east and north, they are found to contain a much greater proportion of fine material than is encountered in digging wells in the center of the valley. This is probably due to the varying conditions under which the material was accumulated. The older parts of the Beaver Lake beds were laid down in Beaver Lake, and coarse and fine materials were deposited together. When the lake ceased to exist because of the filling with sediment on the one hand and the down cutting of the outlet between Adamsville and Minersville on the other, the river deposited only the coarser material within Beaver Basin, carrying the finer material through the outlet to form part of the Lake Bonneville beds of the Escalante Desert. There is furthermore ample evidence in Beaver basin, as in other places throughout the semiarid region of western America, that varied conditions of erosion and deposition have prevailed during recent geologic time. The streams were sometimes depositing sand and gravel

and building up the floors of the valleys and at other times eroding away the material previously laid down. Both operations have had a tendency to cause coarse material to accumulate in the center of the valley. While the river was building up its valley, the finer sediments were carried through to Escalante Bay and the coarser material was dropped within the basin. On the other hand, while the river was eroding, it worked over the sediments previousy deposited in Beaver Basin, bearing away such material as it was able to carry and leaving the heavier rock fragments. In this way the coarser material accumulated in the center of the valley both by direct deposition and by surface concentration of the gravels.

West of Minersville, however, a different set of conditions prevailed. The water-bearing materials there are the lake sediments of the Lake Bonneville beds. The river has deposited comparatively little sediment and there has been practically no erosion since the beds were formed. The sediments in the midst of the desert, extending from the surface to some unknown depth, consist of clay, sand, and fine gravel, as shown by the well records previously given; along the margins they consist of coarser material derived from the neighboring hills. Since the Lake Bonneville beds are lake deposits, the various layers are presumably persistent over considerable areas. For these reasons the waters are mainly artesian and the surface waters of comparatively little importance, as stated in the description of the deep wells of the Milford district.

*Changes in water level.*—On account of the coarseness and unconsolidated condition of the gravels in Beaver Basin, the water moves readily through them and great changes of level are caused at different times of the year. During the winter much of the precipitation is retained in the mountains in the form of snow and little water is spread over the land for irrigation. There is, therefore, in this season a minimum contribution to the underground supply and a general low-water condition prevails in the shallow wells, the lowest stage being reached in February. In the spring, however, the melting snow supplies large volumes of water to the streams, and this in turn is not only spread over the land for irrigation purposes, but great quantities find their way into the gravels, raising the level of the underground water, which reaches its highest stage in July. The extreme difference in level is variously reported, as shown under "Remarks" in Table 4 (pp. 38–39), the greatest variation of water level being 42 feet.

This rise of the underground water causes serious damage in the lowlands, especially during seasons of more than ordinary rainfall, such as the summer of 1906. During the writer's investigations in Beaver Valley from July to September of that year the lowlands of the valley were in a boggy condition approaching that of a swamp.

Fields were observed with crops that could not be harvested because of the swampy condition. Roads were rendered impassable and animals were mired on land which had formerly been dry. In the town of Beaver many of the dooryards were swampy and water filled the cellars and flowed freely from the dug wells, which during the winter have water only at depths of 25 or 30 feet. Many of the streets were impassable, and a general unhealthful condition prevailed throughout the town. The area within the town that was made more or less swampy by the return waters during July, 1906, is shown in fig. 3 (p. 48). The long arm shown on this map extending northward to the Beaver cemetery is due to the irrigation of the gravel bench east of the town, the return waters issuing at the foot of the bench.

## CHEMICAL CHARACTER OF WATERS.

### METHODS OF DETERMINATION.

A chemical outfit for determination of some of the principal elements contained in ordinary waters was taken to Beaver Valley, and a large number of the waters were tested. These field assays, though much less accurate than those made in the laboratory, give a fairly adequate conception of the chemical character of the waters. Although they are not sufficiently exact to be relied on for the minor differences in character, the major differences are plainly brought out, as will be observed by an inspection of the various tables that follow.

In addition to the field assays, laboratory analyses were obtained from three sources: (1) samples of water were sent to the laboratory of the United States Geological Survey and analyzed by W. M. Barr, of the water resources branch; (2) sanitary analyses of four samples of water were made by Herman Harms, of Salt Lake City, State chemist of Utah; and (3) the analyses of water used by the San Pedro, Los Angeles and Salt Lake Railroad have been kindly furnished for this report by E. G. Tilton, chief engineer of the road.

### STREAMS.

The waters of the streams at their points of issuance from the hills are very pure. Farther down the valley they become more highly charged with saline matter, as shown by the assays in Table 5. The chlorine of Beaver River, for example, increases from 9 to 53 parts in a million parts of water between the mouth of the canyon and Minersville, a distance of only 17 miles. There is also a marked change toward alkalinity, the carbonates increasing from 71 to 225 parts in the same distance. It is furthermore to be noted that the alkaline carbonates (sodium carbonate and potassium carbonate), which are not contained in the waters as they issue from the hills, are present farther

downstream. This is probably caused by the entrance of seepage or return waters that are more highly charged with salts than the streams. The spring waters of the valley are also more saline than the streams and contribute in some measure to the increasing salinity toward the lower parts of the valley.

TABLE 5.—*Field assays of stream waters.*

[Parts per million.]

| Source. | Location. | Iron (Fe) | Total alkalinity as $CaCO_3$. | Alkaline carbonates. | Sulphate radicle. ($SO_4$) | Total hardness as $CaCO_3$. | Chlorine (Cl). |
|---|---|---|---|---|---|---|---|
| Beaver River | 4 miles east of Beaver | 0 | 71 | 0 | <35 | 42 | 9 |
| Do | Greenville | 0 | 203 | 21 | <35 | 160 | 30 |
| Do | Minersville | 0 | 182 | 43 | <35 | ..... | 53 |
| Canal | Beaver | 0 | 71 | 0 | 35 | ..... | 15 |
| North Creek | North of Beaver | 0 | 61 | 0 | 35 | ..... | 3 |
| North Creek Canal | .....do | 0 | 71 | 0 | <35 | ..... | 10 |
| North Creek | Greenville | Tr. | 203 | 0 | <35 | ..... | 39 |
| South Creek | South of Beaver | 0 | 71 | 0 | <35 | 45 | 4 |
| Seepage | Beaver | 0 | 253 | 0 | <35 | ..... | 55 |
| Do | Sec. 21, T. 29 S., R. 7 W | 0 | 263 | 0 | 68 | ..... | 247 |
| Do | .....do | 0 | 122 | 0 | <35 | ..... | 25 |
| Seepage (Sly, T. J.) | Sec. 29, T. 28 S., R. 6 W | 0 | 240 | 0 | <35 | ..... | 95 |
| Seepage (Griffiths, T. M.) | Sec. 30, T. 29 S., R. 8 W | Tr. | 410 | 0 | <35 | ..... | 43 |
| Do | Sec. 20, T. 29 S., R. 7 W | Tr. | 240 | 0 | <35 | ..... | 91 |
| Do | Sec. 19, T. 29 S. R. 7 W | 0 | 232 | 0 | 0 | ..... | 19 |

## SPRINGS.

Laboratory analyses were made of the waters of three springs, as previously described (pp. 20, 21), and field assays were made of 15, as shown in Table 6. The same change in character found in the stream waters is seen also in the springs, the waters being purer in the upper parts of the valley than farther down. The average chlorine in the spring waters in the Beaver district is 19 parts per million, in the Greenville district 39, and in the two springs examined near Minersville a still greater amount. The alkalinity increases from 159 parts per million near Beaver to 191 near Greenville and much greater amounts at Minersville. This increase in salinity is evidently caused by the passage of the water through the sands and gravels of the Beaver Lake beds and by the leaching of the land through irrigation.

TABLE 6.—*Statistics of springs in Beaver Valley.*

[Chemical determinations in parts per million.]

| District and owner | Location. | Flow per minute. | Temperature. | Iron (Fe). | Total alkalinity as $CaCO_3$. | Alkaline carbonates. | Sulphate radicle ($SO_4$). | Total hardness as $CaCO_3$. | Chlorine (Cl). | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| BEAVER DISTRICT. | | *Gals.* | °*F* | | | | | | | |
| Baker, ——— | Bakers Canyon | ..... | 56 | 0 | 141 | 0 | 0 | 63 | 20 | |
| Beaver Land and Livestock Co. | Sec. 9, T. 27 S., R. 8 W. | 7 | 48 | ..... | ..... | ..... | ..... | ..... | ..... | |
| Do | Sec. 10, T. 27 S., R. 8 W. | 6 | 62 | ..... | ..... | ..... | ..... | ..... | ..... | |
| Do | Sec. 4, T. 27 S., R. 8 W. | 6 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | |
| Boyter, A | Sec. 9, T. 29 S., R. 7 W. | 50 | ..... | 0 | 121 | 0 | Tr. | ..... | 5 | |
| Cartwright, J. H | Sec. 21, T. 29 S., R. 7 W. | 22 | 52 | 0 | 162 | 0 | Tr. | ..... | 45 | |
| Farnsworth & Bastian Bros. | Sec. 28, T. 28 S., R. 7 W. | 50 | 52 | ..... | ..... | ..... | ..... | ..... | ..... | |
| Gale, O. W | Sec. 4, T. 29 S., R. 7 W. | 305 | ..... | 0 | 203 | 0 | <35 | ..... | 15 | Decreases three-fourths in winter. |
| Gale, Hannah | do | 606 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Decreases one-half by August 1. |
| Gillies, Geo. B | do | 35 | 52 | ..... | ..... | ..... | ..... | ..... | ..... | Maximum flow in June. |
| Gillies, D. M | do | 332 | ..... | 0 | 172 | 0 | <35 | ..... | 49 | Minimum flow in August, one-third of maximum flow. |
| Greene, Henry | Sec. 36, T. 28 S., R. 7 W. | 112 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Minimum flow in February, maximum in July. |
| Jackson, Jos | Sec. 28, T. 29 S., R. 7 W. | 164 | 54 | 0 | 182 | 0 | 0 | ..... | 15 | Minimum flow one-fourth of maximum. |
| Mumford, Geo | do | 180 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | |
| Owens, G. E | Sec. 27, T. 29 S., R. 7 W. | 270 | ..... | 0 | 253 | 0 | 0 | ..... | 34 | Variation in volume one-third. |
| Parkinson, G. A | Sec. 22, T. 29 S., R. 7 W. | 250 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | |
| Patterson, Ed | Sec. 32, T. 29 S., R. 7 W. | 1 | ..... | 0 | 143 | 0 | 0 | ..... | 10 | |
| Sly, T. J | Sec. 29, T. 28 S., R. 6 W. | 90 | ..... | 0 | 61 | 0 | 35 | 63 | 5 | |
| Warby, Isaac | Sec. 35, T. 28 S., R. 7 W. | 256 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Minimum flow in February, maximum in July. |
| White, C. D | Sec. 33, T. 28 S., R. 6 W. | 27 | 62 | ..... | ..... | ..... | ..... | ..... | ..... | |
| Yardley, W. E | Sec. 21, T. 29 S., R. 7 W. | 103 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Decreases one-third in winter. |
| GREENVILLE DISTRICT. | | | | | | | | | | |
| Ashworth, H. H | Sec. 31, T. 29 S., R. 7 W. | 16 | ..... | 0 | 132 | 0 | Tr. | ..... | 20 | |
| Farnsworth, P. T | do | ..... | ..... | 0 | 134 | 0 | Tr. | ..... | 45 | |
| Do | do | ..... | ..... | 0 | 162 | 0 | 0 | ..... | 30 | |
| Gillies & Bro | Sec. 11, T. 27 S., R. 8 W. | 7 | 52 | ..... | ..... | ..... | ..... | ..... | ..... | |
| Green, Henry | Sec. 36, T. 28 S., R. 7 W. | 112 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | |
| Murdock, Chas. and J. M. | Sec. 11, T. 27 S., R. 8 W. | 7 | ..... | 0 | 244 | 0 | Tr. | ..... | 45 | |
| White, C. D | Sec. 31, T. 29 S., R. 7 W. | 12 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Water brackish. |

TABLE 6.—*Statistics of springs in Beaver Valley*—Continued.

[Chemical determinations in parts per million.]

| District and owner. | Location. | Flow per minute. | Temperature. | Iron (Fe). | Total alkalinity as $CaCO_3$. | Alkaline carbonates. | Sulphate radicle ($SO_4$). | Total hardness as $CaCO_3$. | Chlorine (Cl). | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| MINERSVILLE DISTRICT. | | | | | | | | | | |
| | | *Gals.* | *°F* | | | | | | | |
| Dotson, R. W | Sec. 7, T. 30 S., R. 9 W | 57 | 97 | 0 | 205 | 0 | 87 | 300 | 70 | |
| Four miles north of Minersville. | | 50 | | 0 | 243 | 0 | <35 | 236 | 40 | |
| Warm springs | Thermo | | 140 | 0 | 304 | 0 | 124 | | 299 | For exact analysis see Table 9 (p. 50). |
| McKean, P. B | T. 27 S., R. 9 W | 10 | 210 | | | | | | | Roosevelt Hot Spring. For exact analysis see Table 9 (p. 50). |
| Sulphur beds | Cove Creek | | | | | | | | | See description on p. 19. |

### DEEP WELLS.

Field assays were made of the waters of 36 deep wells. In general these show greater quantities of dissolved solids than the springs and shallow wells. The average chlorine in the deep wells near Beaver is 51 parts in a million parts of water, and the average alkalinity 251. For the Greenville region the average chlorine is 44 and the alkalinity 288, for the Adamsville region the average chlorine is 63 and the average alkalinity 255, for the Minersville region the average chlorine is 266 and the average alkalinity 328. A statement of averages in the Milford region would be misleading. The waters are very pure at Milford and very saline in Beaver Bottoms, where the chlorine content reaches a maximum of 1,787 parts per million. The chlorine occurs in these waters in the form of common salt (NaCl) and gives them a strong brackish taste. Exact analyses were made of the waters from two of the wells in the Milford district—the Milford town well and J. C. White's well at Beaver Bottoms. (See Table 9, p. 50).

### SHALLOW WELLS.

Field assays of waters from the shallow wells are given in Table 4 (pp. 38–39). From this table it appears that the waters are variable in character and, like those of the streams, springs, and deep wells, increase in salinity toward the west, or away from the source of supply.

It is noteworthy in this connection that the samples were taken during a time when the water was high, in many places overflowing the wells. The salt content is therefore much less than it would have been at a time of low water. This is shown by the several assays made of water from J. F. Jones's well, in Beaver, given below. The water was flowing from the top of the well August 2, when the first sample was taken. August 24 it had fallen about 1 foot and no longer flowed from the well. September 11 the water surface was 6 feet below the top of the well. The figures here given are perhaps sufficient to show that during the lowest stage the water of some of the wells might be very unhealthful.

*Field assays of water from J. F. Jones's well, Jones Hotel, Beaver.*

[Parts per million. Analyst, Herman Harms.]

| | Aug. 2. | Aug. 24. | Sept. 11. |
|---|---|---|---|
| Iron (Fe) | 0 | 0 | 0.2 |
| Total alkalinity as $CaCO_3$ | 243 | 273 | |
| Alkaline carbonates | 0 | 0 | |
| Sulphate radicle ($SO_4$) | >35 | >35 | 66 |
| Chlorine (Cl) | 65 | 80 | 99 |

BEAVER WELLS.

The variability in character of water in shallow wells is best illustrated by the wells of the town of Beaver, where samples were taken at no great distance apart and on the same day. Although a town of considerable size, Beaver has no water system and no sewers. The people depend for drinking water almost entirely on wells, most of them shallow and open. The town is the center of an agricultural district and according to the general custom in that part of the country, the ranchmen live in the town, driving their herds into the town at night and out of it to pasture in the morning.

Beaver is located in the center of the valley, where the land consists mainly of beds of unconsolidated gravel covered with scanty soil. There is little to prevent surface contamination from entering directly into the wells, and apparently the only reason for the water being in any measure fit for domestic use is that the open condition of the gravels allows the underflow to pass rapidly through them, thus keeping them in some degree cleansed and free from impurities which might otherwise produce serious consequences.

The contamination is strikingly shown by the assays given in Table 7. Several factors should be carefully considered in interpreting this table. The water samples were taken during the highest stage of the underground waters, a time when they contain the least quantity of saline matter. During the lower stages some of these same waters are reported unfit for use. The river water, which is the principal source of the underflow at Beaver, is very pure, as shown by the assay of water taken 4 miles upstream. This assay is placed at the head of Table 7 for comparison. The high chlorine content shown by most of the assays can not be ascribed to residual salt (NaCl) in the sediments of the Beaver Lake beds, in the case of the shallow wells, for the obvious reason that the river and irrigation waters flowing through them are less saline than that of the wells and tend continually to freshen the underground waters.

The only adequate explanation of the large quantities of the various salts in the well waters is that they are due to surface contamination. This explanation is confirmed by the variable amounts of chlorine shown by the assays. The chlorine is probably present in the form of common salt (NaCl) and is the element that shows surface contamination most clearly. The table is arranged to correspond with the map of Beaver (fig. 3), and the numbers in the first column correspond with the location numbers on the map. From an inspection of the table and map it appears that wells only a few rods apart vary greatly in the quantity of chlorine, the minimum amount being 18 and the maximum 303 parts in a million parts of water.

TABLE 7.—*Field assays of well waters in Beaver.*

[Parts per million.]

| No. on fig. 3. | Owner. | Iron (Fe). | Total alkalinity as $CaCO_3$. | Alkaline carbonates. | Sulphate radicle ($SO_4$). | Chlorine (Cl). |
|---|---|---|---|---|---|---|
| | Beaver River, 4 miles east of Beaver | 0 | 71 | 0 | <35 | 9 |
| 1 | Stony, F. J. | 0 | 304 | 0 | Tr. | 18 |
| 2 | Wolfenden, C. | 0 | 344 | 0 | <35 | 70 |
| 3 | Smith, Seth W. | 0 | 243 | 0 | 0 | 65 |
| 4 | Okenden, C. | 0 | 241 | 0 | 35 | 306 |
| 5 | Burt, Wm. | 0 | 264 | 0 | 0 | 28 |
| 6 | Muir, Jno. J. | 0 | 245 | 0 | <35 | 63 |
| 7 | Farnsworth, W. H. | Tr. | 233 | 0 | <35 | 198 |
| 8 | Owens, G. E. | 0 | 253 | 0 | 0 | 35 |
| 9 | Barrachouch, J. | 2 | 253 | 0 | <35 | 50 |
| 10 | Harris, L. H. | Tr. | 252 | 0 | Tr. | 28 |
| 11 | Harris, Lydia | 0 | 283 | 0 | Tr. | 60 |
| 12 | Harris, H. | Tr. | 182 | 0 | <35 | 80 |
| 13 | Brooks, John | 0 | 263 | 0 | <35 | 91 |
| 14 | Atkins, Alice | 0 | 281 | 0 | <35 | 70 |
| 15 | Morgan, Ed. | 0 | 234 | 0 | Tr. | 33 |
| 16 | Lawrence, A. L. | Tr. | 250 | 0 | <35 | 70 |
| 17 | Swindelhurst, E. H. | 0 | 242 | 0 | Tr. | 35 |
| 18 | Wilden, E. | 0 | 121 | 0 | 0 | 25 |
| 19 | Robinson, Eliza | 2 | 223 | 0 | Tr. | 40 |
| 20 | Goodwin, I. S. | 0 | 233 | 0 | Tr. | 51 |
| 21 | Houd, S. F. | 3 | 253 | 0 | Tr. | 47 |
| 22 | Manhardt, W. M. | 0 | 152 | 0 | <35 | 24 |
| 23 | Jones, J. F. | 0 | 273 | 0 | <35 | 80 |

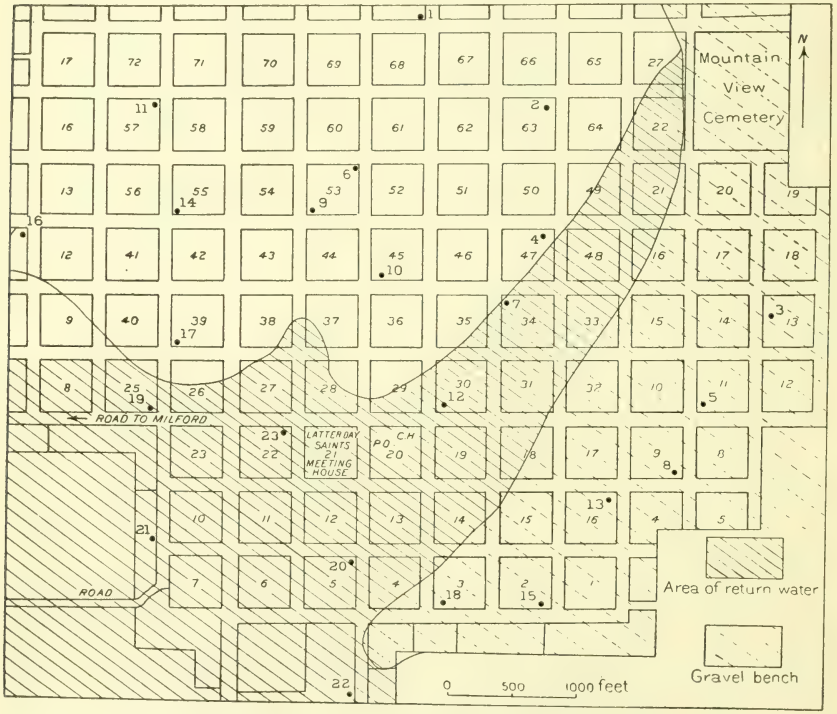


FIG. 3.—Map of Beaver, showing seepage area and location of wells included in Table 7.

### SANITARY ANALYSES.

On account of the obviously unhealthful conditions affecting the waters of Beaver, four samples, taken September 1, 1906, were sent to Herman Harms, of Salt Lake City, State chemist of Utah, for sanitary analysis. The samples represent the principal sources of the water used for domestic purposes in Beaver. The results of Mr. Harms's analyses are given in Table 8. In commenting on them he unqualifiedly condemns the waters as unsuitable for domestic purposes.

TABLE 8.—*Sanitary analyses of Beaver waters.*

[Parts per million. Analyst, Herman Harms.]

| | Canal at Stake Academy building. | Open well (Wm. Thomas, jr.). | Drilled well (J. F. Tolton). | Dug well (J. F. Jones, hotel). |
|---|---|---|---|---|
| Depth.....feet. | Stream. | 46 | 62 | 24 |
| Odor | Faint. | Slight. | Faint. | Marked. |
| Odor on heating | Pronounced. | Pronounced. | Pronounced. | Decided. |
| Nitrates (diphenylamine reaction) | Trace. | Abundant traces. | Trace. | Abundant traces. |
| Nitrites (Greiss-Islosvay reaction): | | | | |
| Cold | Faint. | Abundant. | Trace. | Abundant. |
| Heated to 175° F | Trace. | Abundant. | Decided traces. | Abundant. |
| Hydrogen sulphide ($H_2S$) | 0 | 0 | 0 | 0 |
| Alkaline sulphides | 0 | 0 | 0 | 0 |
| Metallic impurities | 0 | 0 | 0 | 0 |
| Total dissolved solids at 212° F | 409 | 420 | 380 | 633 |
| Calcium chloride ($CaCl_2$) | 0 | 0 | 0 | 0 |
| Magnesium chloride ($MgCl_2$) | 0 | 0 | 0 | 0 |
| Volatile matter | 75 | 80 | 63 | 173 |
| Mineral matter | 354 | 339 | 317 | 459 |
| Chlorine (Cl) | 8 | 33 | 53 | 70 |
| Common salt (NaCl) | 13 | 55 | 87 | 115 |
| Free ammonia | .03 | .14 | .05 | .16 |
| Albuminoid ammonia | .22 | .19 | .12 | .35 |
| Oxygen consumed | 7.12 | 3.00 | 1.66 | 5.38 |

### OTHER EXACT ANALYSES.

Six samples of water were sent to W. M. Barr, of the United States Geological Survey, for laboratory analysis. Three of these were from springs and three from wells. Of the springs one is acid water from the Cove Creek sulphur beds; one from Roosevelt Hot Spring, on the western slope of the Mineral Mountains, the waters of which are supposed to have valuable medical properties; and one from the group of warm springs near Thermo. The samples from the wells were selected to represent the shallow wells of the Beaver region (Jones's well), the artesian wells of the Milford district (Milford town well), and the artesian wells of Beaver Bottoms (J. C. White's well). The analyses are as follows:

TABLE 9.—*Laboratory analyses of water from Beaver Valley, Utah.*

[Parts per million. Analyst, W. M. Barr.]

| Name. | Location. | Source. | Suspended matter. | Total dissolved solids at 180° C. | Silica ($SiO_2$). | Iron (Fe). | Calcium (Ca). | Magnesium (Mg). | Sodium and potassium (Na, K). | Carbonate radicle ($CO_3$). | Bicarbonate radicle ($HCO_3$). | Sulphate radicle ($SO_4$). | Chlorine (Cl). | Nitric radicle ($NO_3$.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| McKean, P. B | Sec. 7 (?), T. 27 S., R. 9 W | Roosevelt Hot Spring | 1,238 | 645 | 101 | 5 | 31 | 9.7 | 102 | 0 | 30 | 90 | 87 | 1.83 |
| Milford | City | Flowing well | [a] 540 | 248 | 35 | .1 | 11.2 | 6.6 | 66 | 0 | 190 | 53 | 13 | .5 |
| Jones, J. F | Hotel | Surface well | 0 | 520 | 40 | .2 | 106 | 29 | 43 | 0 | 276 | 66 | 99 | 1.7 |
| Utah Sulphur Co | Sulphurdale | Sulphur mine | 52 | 10,810 | 124 | 1,362 | 158 | 232 | 144 | 0 | 0 | 7,602 | 79 | 1.7 |
| (?) | Thermo | Warm springs | 0 | 1,620 | 55 | 1.4 | 86 | 11 | 432 | 0 | 414 | 522 | 238 | .0 |
| White, J. C | Beaver Bottoms | Flowing well | 0 | 2,937 | 24 | 0 | 133 | 127 | 727 | 0 | 495 | 35 | 1,570 | .0 |

[a] The suspended matter is largely if not wholly due to the presence of fine sand drawn from the well by the pump. The well has recently been completed and the water-bearing beds had not been entirely cleared of loose sand when the sample was taken.

Several analyses of water used by the San Pedro, Los Angeles and Salt Lake Railroad have been made by Herman Harms, State chemist of Utah. The analyses were made with reference to the use of the waters for boiler purposes. The results are given by Mr. Harms, in grams per United States gallon, in the form of combined salts, but are here reduced to parts per million and to the ionic form in accordance with present usage of the United States Geological Survey.

TABLE 10.—*Analyses of waters from deep wells of San Pedro, Los Angeles and Salt Lake Railroad.*

[Chemical determinations in parts per million. Analyst, Herman Harms.]

| Location. | Depth at which sample was taken. | Total dissolved solids. | Siliceous matter. | Undetermined and loss. | Ferric oxide ($Fe_2O_3$) and aluminium oxide ($Al_2O_3$). | Calcium (Ca). | Magnesium (Mg). | Sodium (Na). | Carbonate radicle ($CO_3$). | Sulphate radicle ($SO_4$). | Chlorine (Cl). |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | | | | | | | | | | |
| Beryl | 207 | 344 | 61 | 49 | 2 | 44 | 12 | 27 | 72 | 29 | 43 |
| Lund (No. 1) | (?) | 485 | 64 | 159 | 4 | 29 | 18 | 46 | 73 | 23 | 70 |
| Lund (No. 2) | 585 | 517 | 68 | 140 | 4 | 45 | 16 | 52 | 93 | 2 | 80 |
| Thermo | 401 | 689 | 161 | 244 | 10 | 32 | 15 | 57 | 84 | 4 | 87 |
| Milford | 305 | 330 | 90 | 137 | 3 | 47 | 10 | 8 | 51 | 0 | 12 |
| Neels (No. 1) | 1,382 | 3,336 | 48 | 544 | 14 | 284 | 3 | 293 | 20 | 658 | [a] 1,065 |
| Neels (No. 2) | 1,398 | 3,345 | 370 | 488 | 13 | 197 | 15 | 691 | 36 | 472 | 1,063 |
| Neels (No. 3) | 1,974 | 2,888 | 39 | 586 | 10 | 239 | 6 | 552 | 25 | 458 | [b] 863 |

[a] Samples taken after pumping 190 hours at 75 gallons per minute.
[b] Samples taken after pumping 38 hours.

## POSSIBILITIES OF DEVELOPMENT.

### SURFACE WATERS.

The surface waters used at the present time for irrigation in Beaver basin might, by proper manipulation, be made to serve a greatly increased acreage with no loss to the land now irrigated, and even, in the case of tracts that are being impaired by the use of too much water, with notable benefit to that land. The distribution of irrigation water at the present time is not under the supervision of any public official, and is wanting in adequate central control of any kind. An effort on the part of the community to bring about the passage and enforcement of some law providing for the equitable distribution of water would undoubtedly result in a great improvement of present conditions.

### UNDERGROUND WATERS.

*Drainage.*—The conditions brought about by the behavior of the underground water in Beaver basin have become serious and are apparently growing worse year after year. According to report, the swampy areas caused by the midsummer rise of the water are increas-

ing in size, and during the summer of 1906 roads and city streets that had never before been affected were rendered impassable, and dwellings that heretofore had been regarded as safe became uninhabitable.

An effort has been made by some of the citizens of Beaver, who realize the serious consequences to health likely to result from these conditions, to secure public action in draining the town or otherwise disposing of the superfluous water, but up to the time of the present writing nothing has been accomplished. The comparatively steep grade of the valley floor renders such drainage possible not only for the towns, but for much of the land which is now useless during the latter part of the summer. It is probable, however, that the water might be controlled more effectively and economically in other ways.

*Pumping plants.*—In many parts of the country where conditions similar to those of Beaver Valley prevail, pumping water for irrigation has proved more satisfactory in many ways than obtaining it by means of seepage ditches, and in view of the favorable conditions in Beaver basin it is probable that the establishment of a large number of pumping plants would not only serve the same purpose as expensive drainage systems in satisfactorily disposing of the overabundant underground water, but would render the water thus obtained more useful, since it could be better controlled and placed where it is most desired for irrigation.

The underground conditions in Beaver basin, so far as they are known, are very favorable for the operation of pumping plants, although no pumping experiments have ever been made there. The gravels are coarse and unconsolidated and the water moves through them with great readiness, as evidenced by the unusual yearly fluctuation of the water level within them. The lift would be small, since the water in summer reaches the surface of the ground over a large area. It is furthermore to be noted in this connection that the underground water reaches its maximum height during the summer—a fact especially favorable to the use of pumps, since the available quantity of water is greatest and the lift least during the time when the water is most needed for irrigation.

It should further be borne in mind that in the spring and early summer, when the maximum amount of water is carried by the streams, the underground water is moderately low. Later in the summer, when the streams are low, the underground waters attain their maximum volume. The increase in volume of the underground waters, although not coincident in time with the increase in volume of the streams, is primarily due to the increase in stream volume and secondarily to the use of the stream waters for irrigation. The lagging in effect is due to the obstruction offered by the sands and gravels to the passage of the water through them. The rain waters, irrigation waters, and stream waters enter the ground wherever it

is porous enough to allow them to pass and gradually work their way down the valley, not in definite or well-defined underground channels, as is often believed, but as a general sheet saturating the sands and gravels of the valley filling. The coarser the material the faster will be the movement; hence there may be courses through the valley filling along which the water moves more rapidly than along others, but these can not be considered as underground channels. The water entering the valley filling at the upper end of the valley works its way slowly downward, as a general saturation of the sands and gravels, the maximum volume reaching a given point long after the time of maximum volume of the surface waters. Thus in Beaver basin the surface waters attain their maximum volume during May and June and the underground waters during July and August.

To judge from experience in other places where large quantities of water are pumped for irrigation, wells might be constructed in Beaver basin similar to those extensively used in southern California and in the Salt River Valley of Arizona,[a] with casing perforated from top to bottom, since the gravels are sufficiently coarse to act as strainers, and by means of centrifugal pumps such wells might be made to yield large quantities of water. It is within conservative limits to state that a single, properly constructed 12-inch well, 100 feet or less in depth, would easily yield 1,000 gallons of water per minute, a quantity more than sufficient to irrigate the average-sized ranch in Beaver Valley.

For the economic use of pumps for irrigation a convenient source of power is necessary. This is being provided for Beaver Valley. The Telluride Power Company has undertaken the construction of a large electric plant in Beaver Canyon, known locally as the Puffer Lake site, and the work of construction was begun during the autumn of 1906. The main object of the company is to produce power for use at the mines in the vicinity of Beaver Valley, but one of the transmission lines will pass through Beaver Basin, and power for pumping can probably be furnished at rates much cheaper than it can be produced in any other way.

Since no development of the underground waters of Beaver Basin has been effected, there is no information at hand by which their available quantity can be estimated, but to judge from the quantities pumped in Salt River Valley, Arizona, in southern California, and in other places where the underground conditions are similar to those in Beaver Basin, many hundreds of acres might be irrigated with pumped water in this valley. The writer is of the opinion that with the proper conservation and distribution of the surface waters, as previously suggested, and the development of the underground

[a] Lee, W. T., Underground waters of Salt River valley, Arizona: Waters-Sup. and Irr. Paper No. 136, U. S. Geol. Survey, 1905.

waters, the acreage of cultivated land in Beaver Valley might easily be doubled.

*Artesian conditions.*—Water occurs under sufficient pressure in both the Beaver Lake and the Lake Bonneville beds to produce flowing wells. In the Beaver Lake beds the flow is probably due to the comparatively steep gradient of the surface of the underground water rather than to confinement of the water under impervious layers of rock. The sediments are apparently porous throughout and the underground water tends to return to the surface in the lowest parts of the valley. A well bored in the sediments furnishes an easier way of escape for the waters than the passage through the gravels. The slight pressure of the water in the flowing wells and the fact that only such wells flow as are located in or very close to areas where the underground water reaches the surface indicates the probable absence of any impervious layer that would tend to hold the waters in confinement. In other words, the Beaver Lake beds are not constituted in the manner commonly understood as necessary for the occurrence of artesian wells. The beds may rather be termed subartesian. Furthermore, the area in which flowing water is to be found is very small and nothing more is to be expected of the wells than to furnish a moderate supply of water for domestic purposes.

In the Lake Bonneville beds of the Escalante Desert, however, a different set of conditions prevail. Here the water is much less in volume than in the Beaver Lake beds, but the constitution of the sediments is such that the supply is better conserved. The Lake Bonneville beds are made up of alternating layers of sand, fine gravel, and clay. The sands and gravels are porous, allowing the water to work its way slowly through them, while the clay is impervious, thus retaining the water in confinement within the porous layers.

Much more is to be expected of flowing wells in the Escalante Desert than in Beaver Basin on account of the great volume of the Lake Bonneville beds. Although the small supply of water entering these beds is unfavorable to the occurrence of any great quantity of underground water within them, the great mass of the sediments and the fact that they are now saturated with water assures the permanence of the water supply for a long time to come. In the absence of experiments it is uncertain whether the underground waters could be obtained in sufficient quantity and at a cost sufficiently low to render them useful in irrigation; but it is reasonably certain that enough water for stock-raising purposes could be obtained throughout the Escalante Desert to make useful in this way a large territory that is now practically unproductive.

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

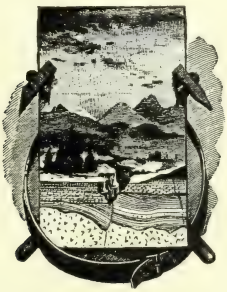
WATER-SUPPLY PAPER 218

# WATER-SUPPLY INVESTIGATIONS IN ALASKA, 1906–1907

## NOME AND KOUGAROK REGIONS, SEWARD PENINSULA; FAIRBANKS DISTRICT, YUKON-TANANA REGION

BY

FRED F. HENSHAW AND C. C. COVERT



WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

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# WATER-SUPPLY INVESTIGATIONS IN ALASKA, 1906–1907.

By Fred F. Henshaw and C. C. Covert.

## INTRODUCTION.

### SCOPE OF WORK.

For a number of years the United States Geological Survey has made systematic measurements and studies of the water supply as one of the great resources of the country. These data are now available for all the more important streams in the United States and are extensively used by engineers and others in problems involving water power, city water supply, irrigation, and manufacturing.

The development of the important placer-mining fields of Alaska, notably those of Seward Peninsula and the Yukon-Tanana region, is intimately associated with the successful utilization of their water supplies. A knowledge of the amount of water available in the streams would have prevented most of the failures that have been made in the past, and will be invaluable in connection with future developments.

There is a great tendency in Alaska to push forward the construction of ditches without first making sure of the primary requisite of their successful operation—an adequate water supply. The results of such a policy were forcibly shown during last summer in Seward Peninsula, in some parts of which a severe drought caused much loss and inconvenience to mining operators. These conditions are apt to occur in any portion of Alaska, and too much stress can not be laid on the importance of stream-flow data. The low-water period lasts only a part of the season and the water supply is usually sufficient at other times, but in view of the other unfavorable conditions—the shortness of the season, the frozen ground, the distance from base of supplies and consequent high cost of transportation—a reduction of even two or three weeks in the working season may mean the difference between profit and loss. The cost of the useless machinery and ditches which can be seen in some parts of Alaska amounts to hundreds of thousands

of dollars, and most of this could have been saved by a preliminary investigation of conditions by a competent engineer.

Hydraulic developments have been carried farthest in the Nome region of Seward Peninsula, which has been an important producer of placer gold since 1899. Hundreds of miles of mining ditches have been built at a great expense. When it was decided in 1906 to extend stream-gaging work to Alaska, the Nome region was accordingly selected as the first district to be studied. A reconnaissance was made and gaging stations were established by John C. Hoyt in the early summer of 1906, and the work was then carried on until the end of the season by Fred F. Henshaw. During last season the work was continued by Mr. Henshaw, assisted by Raymond Richards, and was extended into the Kougarok region, north of the Kigluaik Mountains, in the central portion of Seward Peninsula. Altogether the parties were in Seward Peninsula from June 11 to October 3, 1906, and from June 11 to October 14, 1907.

The collection of stream-flow records was begun in the Fairbanks district of the Yukon-Tanana region by C. C. Covert in 1907. The work was largely that of reconnaissance, but a few regular stations were established.

The work of collecting the data and preparing this report was done under the direction of the water resources branch by engineers detailed for the purpose. The expenses were paid out of the appropriation for investigating the mineral resources of Alaska, and the field work has been under the general supervision of Alfred H. Brooks, geologist in charge of Alaskan work.

## COOPERATION.

The funds available for the work were inadequate to cover properly the large extent of country on which it was desirable to obtain records. It was possible to obtain daily gage readings only through the hearty cooperation of mining operators, ditch companies, and others. Those to whom special acknowledgment is due are named below:

In the Nome region, to the officers and employees of the Miocene Ditch Company, Wild Goose Mining and Trading Company, Cedric Ditch Company, Pioneer Mining Company, Gold Beach Development Company, and the United Ditch Company; to W. L. Leland, of the Three Friends Mining Company; to J. E. Styers, superintendent of construction for the National Wood Pipe Company; and to Arthur Gibson, George Ashley, William E. Morris, J. Potter Whittren, Mark N. Alling, and George M. Ashford, civil and mining engineers, Nome.

In the Kougarok region, to the officers and employees of the Kougarok Mining and Ditch Company, Taylor Creek Ditch Company, Pittsburg-Dick Creek Mining Company, Irving Mining Company,

Cascade Mining and Ditch Company, Ottumwa Gold Mining Company, and to others for information and accommodations in camp.

In the Fairbanks district, to John Zug, superintendent good roads commission; A. D. Gassaway, general manager of the Chatanika Ditch Company; Falcon Joslin, president of the Tanana Mines Railroad Company; Herman Wobber, Fairbanks Creek; C. D. Hutchinson, electrical engineer, Tanana Electric Company, and Martin Harris, Chena.

## EXPLANATION OF DATA AND METHODS.

The methods of carrying on the work and collecting the data were substantially the same as those previously used for similar work,[a] but were adapted to the special conditions found in Seward Peninsula.

In the consideration of industrial or mining enterprises which use the water of streams, it is essential to know the total amount of the water flowing in the stream, the daily distribution of the flow, and facts in regard to the conditions affecting the flow. Several terms are used, such as second-foot, miner's inch, gallons per minute, etc., to describe the quantity of water flowing in a stream, the one selected depending on the use to be made of the data.

"Second-foot" is in most general use for all classes of work, and from it the quantity expressed in other terms may be obtained. It is an abbreviation of cubic foot per second and may be defined as the quantity of water flowing per second in a stream 1 foot wide and 1 foot deep at the rate of 1 foot per second. It should be noted that it is a rate of flow, and to obtain the actual quantity of water it is necessary to multiply it by the time.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly, as regards both time and area.

"Run-off in inches" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is expressed in depth in inches.

"Acre-foot" is equivalent to 43,560 cubic feet, and is the quantity required to cover an acre to the depth of 1 foot. It is commonly used in connection with storage problems.

The "miner's inch," the unit used in connection with placer mining, also expresses a rate of flow, and is the quantity of water flowing through an orifice of a given size, with a given head. The head and size of the orifice used in different localities vary, thus making it a most indefinite and unsatisfactory unit. Owing to the confusion

[a] See Water-Sup. and Irr. Papers Nos. 94, 95, and 201, U. S. Geol. Survey.

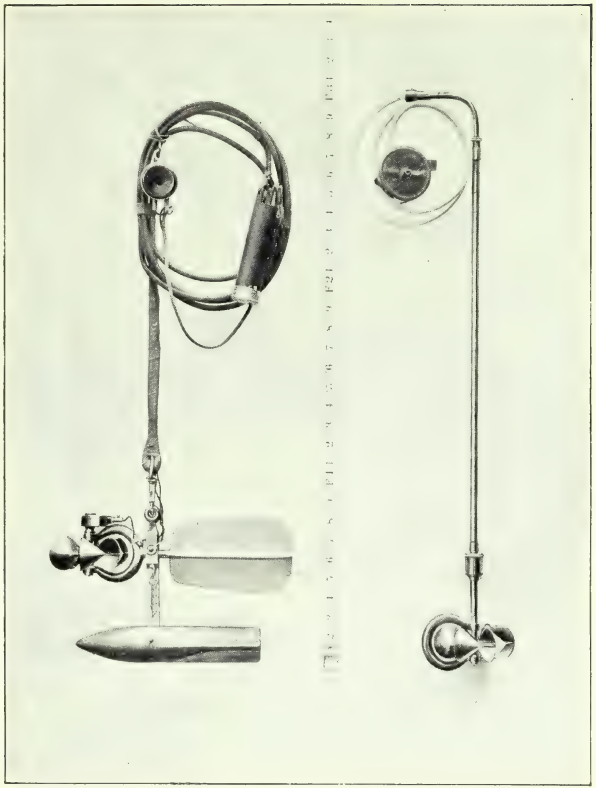
arising from its use, it has been defined by law in several States. The California miner's inch is in most common use in the United States and was defined by an act approved March 23, 1901, as follows: "The standard miner's inch of water shall be equivalent or equal to $1\frac{1}{2}$ cubic feet of water per minute, measured through any aperture or orifice." This miner's inch corresponds to the so-called "6-inch pressure" and is one-fortieth of a second-foot. The inch in most common use in Seward Peninsula is the "old California inch," which was the standard in that State prior to the passage of the above act and is equivalent to 1.2 cubic feet per minute, or one-fiftieth of a second-foot.

Following is a list of convenient equivalents for use in hydraulic computations:

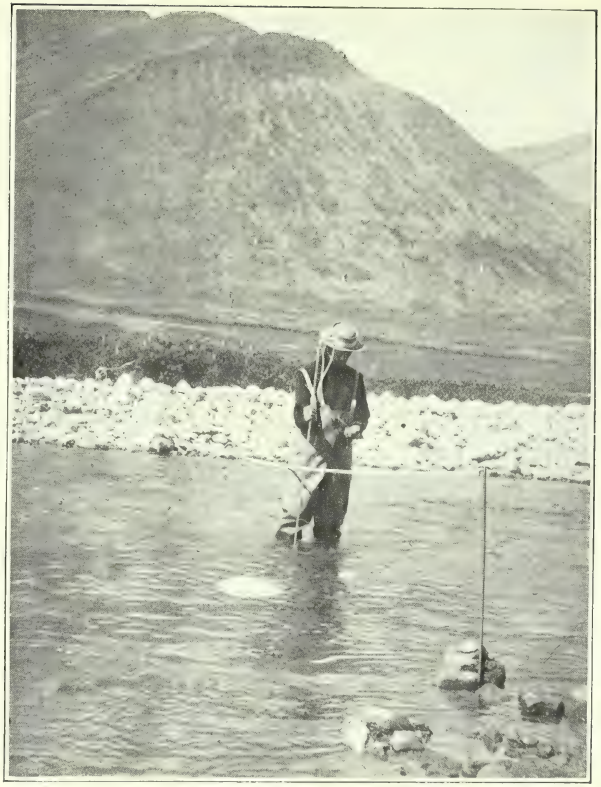
1 second-foot equals 40 California miner's inches (law of March 23, 1901).
1 second-foot equals 50 "old California" miner's inches (used prior to law of March 23, 1901).
1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,272 gallons for one day.
1 second-foot for one year covers 1 square mile 1.131 feet, or 13.572 inches deep.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot for one day covers 1 square mile 0.03719 inch deep.
1 second-foot for one day equals 1.983 acre-feet.
100 California miner's inches equal 15.7 United States gallons per second.
100 California miner's inches for one day equal 4.96 acre-feet.
100 United States gallons per minute equal 0.223 second-foot.
100 United States gallons per minute for one day equal 0.442 acre-foot.
1,000,000 United States gallons per day equal 1.55 second-feet.
1,000,000 United States gallons equal 3.07 acre-feet.
1,000,000 cubic feet equal 22.95 acre-feet.
1 acre-foot equals 325,850 gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-foot per year.
1 mile equals 5,280 feet.
1 acre equals 43,560 square feet.
1 acre equals 209 feet square, nearly.
1 cubic foot equals 7.48 gallons.
1 cubic foot of water weighs 62.5 pounds.
1 horsepower equals 550 foot-pounds per second.
1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.80 feet.
$1\frac{1}{3}$ horsepower equal about 1 kilowatt.

To calculate water power quickly: $\frac{\text{Sec. ft.} \times \text{fall in feet}}{11}$ = net horsepower on water-wheel realizing 80 per cent of theoretical power.

The determination of the quantity of water flowing past a certain section of a stream at a given time is termed a discharge measurement. The quantity is the product of two factors—the mean velocity and the area of the cross section. The mean velocity is a function of surface slope, wetted perimeter, roughness of bed, and the channel conditions at, above, and below the gaging section. The area depends on the contour of the bed and the fluctuations of the



*A*. PRICE CURRENT METERS.



*B*. MEASURING GRAND CENTRAL RIVER.

surface. The two principal ways of measuring the velocity of a stream are by floats and current meters.

All current-meter measurements are made by the engineers of the Survey, but as float measurements can readily be made by the prospector the method is described below.

The floats in common use are the surface, subsurface, and tube or rod floats. A corked bottle with a flag in the top and weighted at the bottom makes one of the most satisfactory surface floats, as it is affected but little by wind. In flood measurements, good results can be obtained by observing the velocity of floating cakes of ice or débris. In all surface-float measurements the observed velocity must be multiplied by 0.85 to 0.90 to reduce the surface velocity to the mean velocity. The subsurface and tube or rod floats are intended to give directly the mean velocity in the vertical. Tubes give excellent results when the channel conditions are good, as in canals.

In measuring velocity by a float, observation is made of the time taken by the float to pass over the "run"—a selected stretch of river from 50 to 200 feet long. In each discharge measurement a large number of velocity determinations are made at different points across the stream, and from these observations the mean velocity for the whole section is determined.

The area used in float measurements is the mean of the areas at the two ends of the run and at several intermediate sections.

The essential parts of the current meters in use are (1) a wheel of some type so constructed that the impact of flowing water causes it to revolve and (2) a device for recording or indicating the number of revolutions. The relation between the velocity of the moving water and the revolutions of the wheel is determined for each meter. This rating is done by drawing the meter through still water for a given distance at different speeds and noting the number of revolutions for each run. From these data a rating table is prepared which gives the velocity per second for any number of revolutions. Many kinds of current meters have been constructed.

The small Price acoustic meter (see Pl. I, *A*) was used exclusively in the work in Alaska. Measurements were made by wading, except on Kruzgamepa River, where a cable and car were installed for use during high stages.

In making a measurement a tape line is stretched across the stream (see Pl. I, *B*) and depth and velocity are measured at regular intervals (from 1 to 5 feet apart, depending on the size of the stream). The depths from which the area of the cross section is computed are taken by soundings with a graduated rod. The velocities are measured by a current meter.

Three methods of measuring the velocity were used. In the first the meter is held at the depth of the thread of mean velocity, which has been shown by extensive experiments to occur at about 0.6 of the

total depth. In the second method the mean of the velocities taken at 0.2 and 0.8 depth is taken as the mean. In the third method the meter is held at mid depth and about 0.1 of the total depth below the surface and above the bottom, and one-fourth of the sum of the top and bottom and twice the mid depth is used as the mean. This method is not adapted to very shallow streams or to those with extremely rough beds.

One of the general laws of the flow of streams with permanent cross sections is that the discharge varies directly with the stage, or gage height, and that it will be the same whenever the stage or gage height of the stream is the same. Therefore, in order to determine the daily discharge of a stream, a gage on which the fluctuations of the surface of the stream may be noted is installed and read daily. As the discharge regularly increases with the stage, it is possible with a few discharge measurements taken at various stages to construct a rating curve which will give the discharge at all stages. The beds of most of the streams measured changed but little during the season and it was therefore possible to obtain the daily flow as just stated.

Water to be of use for mining purposes must be available under considerable pressure, or when diversion is necessary it must be taken at an elevation high enough to allow it to be carried over the divides. The gaging stations, therefore, were so established as to obtain measurements at points whose elevations were sufficient to permit the stream to be diverted for use in mining on the ground already prospected. Such stations were established on all the important streams in the area. At some of the locations it was impossible to secure gage readers to take the daily observations of river height, and for these stations, therefore, it is possible only to give the flow at the time of the actual discharge measurements.

# THE NOME REGION.

By Fred F. Henshaw.

## DESCRIPTION OF AREA.

The area to which the term "Nome region" is applied is, in a general way, 15 to 20 miles wide and stretches 40 miles inland from the town of Nome, which is situated on the southern coast of Seward Peninsula. Most of the measurements recorded in this paper were made about 20 to 25 miles from the coast, at points where the altitude is sufficiently high to make the water available for mining high-level placers, but some trips were also made into the adjacent regions to the east and west.

The region embraces three types of topography, which, from south to north, are (1) a coastal plain, (2) an upland, and (3) a mountain mass.

Bordering the coast line between Cape Nome and Cape Rodney is an area of low relief, which stretches back to the foothills with a width of 2 to 5 miles. This lowland, known as the "Nome tundra," is made up in general of wet, moss-covered ground, rising with a gentle slope to an elevation between 200 and 300 feet at the southern margin of the upland.

The ridges that constitute the upland trend in a general way north and south, rising from about 700 feet near the coast to 2,000 feet 30 miles inland. These ridges are separated by the broad U-shaped valleys of the larger drainage courses. Thirty miles from the coast the ridges are united by an east-west ridge, which presents a steep escarpment toward a broad depression to the north. This depression separates the upland from the Kigluaik Mountains.

The east-west ridge is broken by broad, low gaps, a feature of great importance to the engineer who contemplates tapping the water resources of the Kigluaik Mountains. North of the depression the Kigluaik Mountains, locally known as the Sawtooth Range, rise abruptly, constituting a rugged east-west mass, sharply dissected, with serrated crest line. As these mountains have been the center of local glaciation in recent times, their valleys are characterized by cirques, which form important sources of water for the district.

Most of the area here considered drains southward to Bering Sea through Nome and Snake rivers, whose sources lie close to the ridge which forms the northern boundary of the upland. A part of the waters of the upland also flows southward to Bering Sea through Eldorado, Flambeau, Cripple, and Penny rivers. The valleys of all of these streams are of about the same type—broad and deep in the

upland, with gentle slopes for 300 to 600 feet, then with steeper walls which rise to crest lines ranging from 800 to 1,500 feet in altitude. Their floors are usually covered with gravels. Some of the smaller tributaries occupy sharply incised trenches and have but a thin coating of gravel on their rock floors.

The east-west depression which separates the upland from the mountains to the north is drained in part by streams flowing westward to Sinuk River, which empties into Bering Sea, and in part by streams flowing eastward to Kruzgamepa River, which discharges into Imuruk Basin. The streams draining the southern slope of the Kigluaik Mountains are all tributary to one or the other of the two systems. Many of them head in glacial cirques and flow through steep-walled rock-bound valleys, and all have torrential courses.

The general character of all the drainage areas is the same. (See Pl. II.) The streams have little slope, except in their extreme upper portions, and spread over wide gravelly beds, in which many of them divide into several channels or disappear in the gravel. The channels are also subject to considerable shifting during floods. For 1,000 to 3,000 feet on either side of this gravelly bed extend level or gently sloping bottom lands, from which the hills rise abruptly. The drainage basins are from 4 to 12 miles wide. Most of the tributary streams are short and flow in narrow ravines having steep sides. Their slope is great, and many of them are made up of a series of rapids, waterfalls, and pools.

Practically the whole country to an elevation of 1,000 feet is covered with a thick turf, commonly known as "tundra." (See Pl. III, *A*.) In the summer this turf carries a rank growth of grass dotted with wild flowers of many varieties, and in some areas there is considerable moss. There are no trees with the exception of scattered patches of scrub willow and alder, which in the absence of better fuel can be used for firewood. Much of the ground remains frozen within 2 feet of the surface throughout the year. The soil in the lowlands is mostly gravel, overlain with muck, which contains a large percentage of water, and, when it thaws out in summer, becomes very soft. Considerable areas are underlain by clear ice. The hills are composed largely of schist and limestone rock, mantled with loose slide and gravel.

The Nome region has been an important producer of placer gold since 1899. During the first two or three years operations were confined largely to the shallower and richer creeks and to the present beach. They were carried on by the primitive methods of rocking and shoveling in, and the producing creeks themselves usually furnished an adequate sluice head.

During the last five or six seasons the operations have been of two widely different kinds, namely, underground and hydraulic mining.

TYPICAL TOPOGRAPHY, SEWARD PENINSULA.

The ancient beaches, notably the so-called third beach, have yielded the largest production during the last four years. The work is carried on underground, by shaft and drift, largely in the winter, the material being sluiced with water derived from the melting snow in the spring. Owing to the small yardage moved and the high tenor of the gravels, the problem of obtaining a water supply for sluicing is relatively unimportant. Pumping by gasoline engine is often resorted to and does not materially increase the total cost of mining. In hydraulic mining the conditions are radically different. The chief requirements are a large body of gravel carrying values and an abundant supply of water under a high head.

The stream-gaging work of the Survey in this district has been carried on for the purpose of obtaining accurate information in regard to its water resources, developed and undeveloped, and their adaptation both for placer mining and power. Most of the work in the Nome region in 1907 was done by Raymond Richards, and much credit is due him for the careful and thorough manner in which he carried it on.

The work has been confined to the comparatively small area from which water has been or can be diverted for working the rich placer deposits near Nome. The gaging stations were so located that the measurements would show the water available in this important area. The additional water supply below the points of measurement may on many streams have a local value, and all the streams in the vicinity of the gold-bearing ground of Seward Peninsula are of more or less economic importance, but it was impossible to measure them all on account of inadequate funds.

The results obtained in 1906 have been published, but are included in this report in order to bring all the records up to date.[a]

The data obtained give a fair idea of conditions of flow that may be expected from other areas in the vicinity, provided allowance is made for difference in rainfall, topography, and soil. For this purpose a summary of the flow from different areas has been prepared. (See p. 95.)

## CONDITIONS AFFECTING WATER SUPPLY.

Three sources of water supply contribute to the run-off of Seward Peninsula—summer rains, melting of accumulated snow, and melting of the frozen ground.

Comparatively few data concerning the rainfall are available for years prior to 1906, when rainfall records were begun by the Geological Survey in connection with the investigations of stream flow.

[a] Hoyt, J. C., and Henshaw, F. F., Water supply of Nome region, Seward Peninsula, 1906: Water-Supply and Irrigation Paper No. 196, U. S. Geological Survey. The edition of this paper is completely exhausted.

Records were received from three stations in 1906 and from six in 1907. The daily and monthly rainfall at these points is given on pages 136 to 138.

In the opinion of the mining operators at Nome, the season of 1907 was one of the best for water supply since the settlement of the region, whereas 1906 was about the poorest. An examination of the tables of rainfall will reveal the fact that this difference must have been due less to the greater total rainfall of 1907 than to its more even distribution through the season. A brief statement of climatic conditions for the last nine years is given on page 135.

At Salmon Lake the total rainfall from June to September was greater in 1906 than in 1907 by nearly 2 inches, but as almost half of the total fell in six days during the heavy storms of July 8 to 10 and September 19 to 21, the minimum flow was smaller and lasted longer than in 1907.

The record of snowfall for the winter of 1906–7 at Nome is the only one available. The total (88.7 inches) was abnormally high, and was perhaps double that of some other years. The snowfall in the Kigluaik Mountains is probably much larger than that on the coast.

In 1906 most of the snow in this region had melted before the 1st of June. Only the drifts in the gulches and along the north sides of the hills and the ice banks along the beds of the rivers remained after the 15th. The spring of 1907 was much later and the snowfall of the previous winter was heavier. On June 15 the ground in the mountains was still largely covered with snow, and the daily fluctuation of Nome River, due to the more rapid melting of the snow in the daytime, continued until about July 20.

With the exception of Sinuk and Nome rivers, which have their sources in the mountains a short distance apart, the streams flowing into Bering Sea rise in the foothills of the Kigluaik Range. Their drainage areas have a southern exposure and the snow on them melts early in the season. They are, therefore, dependent for their water supply mostly on the summer rains. The cirques in the Kigluaik Mountains are more protected and hold their snow later in the season, so that the flow of the streams which rise in them is much better sustained.

Some water finds its way into the streams from the melting of the frozen ground. The frozen muck and ground ice, which carry a large amount of water, are protected with a thick coating of moss, through which the heat of summer hardly penetrates, and therefore they thaw very little. The gravelly and sandy soils, which often thaw to a considerable depth, contain much less water. This source of water supply is of minor importance.

In the Nome region there is much ground which becomes thawed and takes up the rain as ground storage, especially late in the season.

*A*. TUNDRA BETWEEN BEACH AND FOOTHILLS.

*B*. MIOCENE DITCH AT GLACIER CREEK.

The coming of the frosts, however, checks the flow of the ground water.

Owing to the steep slopes, the thinness of the surface covering, and the shallow depth to which the ground thaws, the water from the rains finds its way into the streams in a very short time, and the streams rise and fall very rapidly. (See fig. 1.) During the heavy

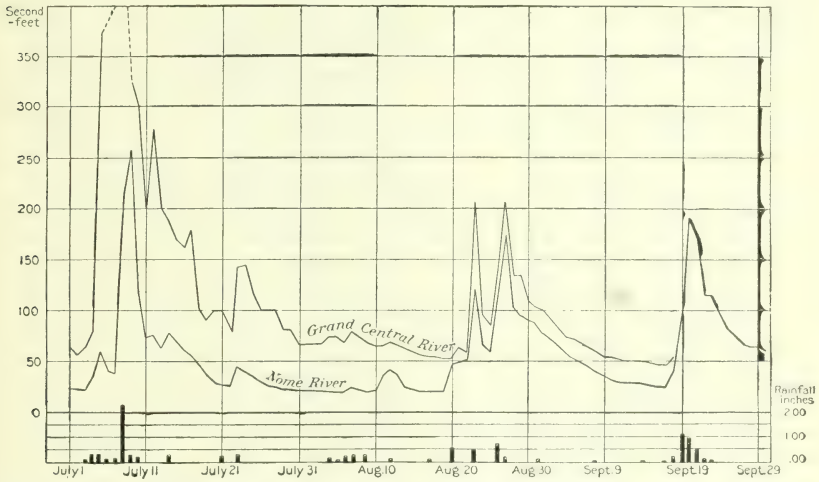



FIG. 1.—Diagram showing flow of Nome River above Miocene intake and of Grand Central River below the forks in 1906.

storm of July 8, 1906, it was noted that although all supply gates of the Miocene ditch were closed and the waste gates were open, the ditch was running full from the rain water coming in from the slopes above. Owing to this lack of ground storage, which is one of the important factors in maintaining a well-sustained stream flow in warmer climates, the streams depend in great part on the rainfall and melting snow for their supply and respond very quickly to an increase or decrease in either. If two or three weeks pass with hardly any rain, as during the last week in July and the first half of August in both 1906 and 1907, the streams will fall rapidly.

A notable feature of many drainage basins is the occurrence of limestone springs. These tend to produce a very uniform flow, and when the entire flow is from this source, as in the case of Hobson Creek, the variation in discharge is small. Other streams deriving much of their discharge from springs are Morning Call Creek and Grand Central River in the Nome region, North Fork and Budd Creek in the Kougarok region, and many creeks in the Solomon and Casadepaga regions.

## GAGING STATIONS.

The following list gives the points in the Nome region at which gages were established or discharge measurements made in 1906 and 1907. The numbers refer to Pl. IV.

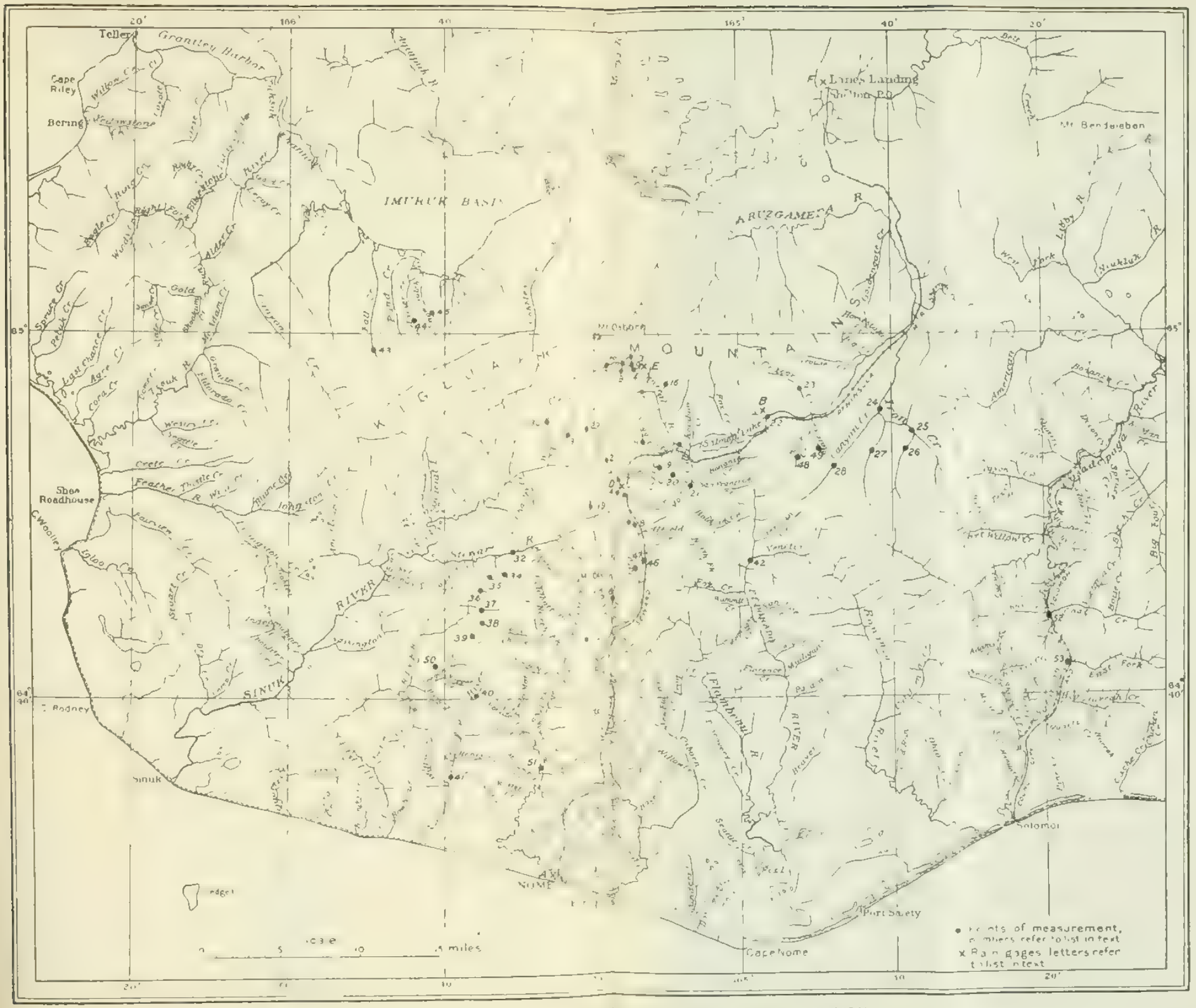
*Gaging stations in Nome region.*

1. Nome River above Miocene intake.
2. Buffalo Creek.
3. Dorothy Creek.
4. Miocene ditch at Black Point.
5. Miocene ditch at flume.
6. Hobson Creek at Miocene ditch crossing.
7. David Creek ditch intake.
8. Seward ditch intake.
9. North Fork of Grand Central River at elevation 750 feet.
10. North Fork of Grand Central River at elevation 1,030 feet.
11. West Fork of Grand Central River at elevation 860 feet.
12. West Fork of Grand Central River at elevation 1,010 feet.
13. Crater Lake outlet.
14. Grand Central River below forks.
15. Grand Central River below Nugget Creek.
16. Gold Run.
17. Thompson Creek.
18. Nugget Creek.
19. Copper Creek.
20. Jett Creek.
21. Morning Call Creek.
22. Kruzgamepa River at outlet of Salmon Lake.
23. Crater Creek.
24. Iron Creek below mouth of Canyon Creek.
25. Iron (Dome) Creek.
26. Eldorado Creek.
27. Discovery Creek.
28. Canyon Creek.
29. Sinuk River.
30. Windy Creek.
31. North Star Creek.
32. Stewart River.
33. Slate Creek.
34. Josie Creek.
35. Irene Creek.
36. Jessie Creek.
37. Upper Oregon Creek.
38. Slate Creek.
39. Aurora Creek.
40. Penny River at elevation 420 feet.
41. Penny River at elevation 120 feet.
42. Eldorado River.
43. Fall Creek.
44. Glacier Creek.
45. Snow Gulch.
46. Nome River at Pioneer intake and Pioneer ditch.
47. Miocene ditch at Clara Creek.
48. Rock Creek.
49. Slate Creek.
50. Cedric ditch above penstock.
51. Snake River above Glacier Creek.
52. Solomon River below Johns Creek.
53. Solomon River below East Fork.

## NOME RIVER DRAINAGE BASIN.

### GENERAL DESCRIPTION.

Nome River is formed by the junction of Buffalo and Deep Canyon creeks, which have their sources in the Kigluaik Range. It has a drainage area of 150 square miles and flows in a general southerly direction through a valley having a length of about 40 miles and a width ranging from 4 to 6 miles. The elevation at the headwaters is between 3,000 and 4,000 feet, and the altitude of the ridges that bound the valley on the east and west averages 1,000 feet. The principal tributaries are David, Sulphur, Darling, Buster, and Osborn




MAP SHOWING LOCATION OF GAGING STATIONS IN NOME REGION.

creeks from the east and Divide, Dorothy, Clara, and Hobson creeks from the west.

Nome River is the most important source of water for use in hydraulicking the rich placer deposits on the old beach lines back of Nome. Four ditches have been built to divert water for mining purposes. These systems, with the elevations of their intakes, are the Campion, 610 feet; Miocene, 572 feet; Seward, 407 feet; and Pioneer, 330 feet.

Any additional water supply that may be obtained in other high-level streams can best be brought to the mines by way of the valley of Nome River. During the seasons of 1906 and 1907 the waters of Nugget, Copper, and Jett creeks were diverted over the Nugget divide by branches of the Miocene system.

Discharge measurements made in this drainage area are given in the following pages.

### NOME RIVER ABOVE MIOCENE INTAKE.

This station, elevation about 575 feet, is located between the junction of Buffalo and Deep Canyon creeks and the intake of the Miocene ditch. At low water the river at this point has a width of about 30 feet, a depth of 1½ feet, and a mean velocity of 1 foot per second. The gage was read twice daily by employees of the Miocene Ditch Company.

The flow at this station is affected by four ditches—the Campion ditch, which diverts water above the station, and the Jett Creek, David Creek, and Grand Central ditches, which bring in water above the station from areas outside the Nome River basin. In order to obtain the natural flow of the river, the mean flow of the Campion ditch has been added to the flow at the gaging station and the flow of the other three ditches subtracted.

*Discharge measurements of Nome River above Miocene intake in 1906-7.*

[Elevation, 575 feet.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-ft.* | 1907. | *Feet.* | *Sec.-ft.* |
| June 17 [a] | ..... | 39 | June 22 | 1.25 | 141 |
| June 28 | 0.15 | 28 | June 30 | 1.09 | 95 |
| July 3 | .00 | 21 | July 10 | .95 | 120 |
| July 5 | .45 | 54.7 | July 12 | .78 | 74 |
| July 14 | .40 | 50.5 | July 17 | .60 | 43 |
| Do | .82 | 117 | August 4 | .44 | 37 |
| August 3 | —.01 | 21.4 | Do | .36 | 37 |
| August 23 | .87 | 121 | August 7 | .25 | 25 |
| Do | .70 | 87 | August 17 | .75 | 82 |
| | | | Do | .68 | 72 |
| 1907. | | | September 4 | .53 | 48 |
| June 21 | 1.25 | 135 | September 9 | .96 | 124 |

[a] One-half mile above Dorothy Creek

*Daily gage height and discharge of Nome River at Miocene intake, 1906-7.*

[Drainage area, 15 square miles.]

| Day. | 1906. | | | | | | 1907. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July. | | August. | | September. | | June. | | July. | | August. | | September. | |
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Ft.* | *S. ft.* | *Ft.* | *S. ft.* | *Ft.* | *S. ft.* | *Ft.* | *S. ft.* | *Ft.* | *S. ft.* | *Ft.* | *S. ft.* | *Ft.* | *S. ft.* |
| 1 | ..... | 23 | 0.02 | 22 | 0.61 | 78 | ..... | ..... | 1.19 | 122 | 0.51 | 38 | 0.57 | 54 |
| 2 | ..... | 23 | .00 | 21 | .57 | 72 | ..... | ..... | 1.06 | 88 | .49 | 36 | .50 | 47 |
| 3 | 0.00 | 21 | −.01 | 21 | .52 | 65 | ..... | ..... | 1.03 | 80 | .48 | 35 | .50 | 47 |
| 4 | .25 | 35 | −.02 | 20 | .46 | 57 | ..... | ..... | .94 | 117 | .45 | 33 | .53 | 50 |
| 5 | .48 | 59 | −.04 | 20 | .42 | 52 | ..... | ..... | .94 | 117 | .33 | 32 | .48 | 45 |
| 6 | .31 | 40 | −.04 | 20 | .40 | 49 | ..... | ..... | 1.08 | 168 | .33 | 32 | .46 | 42 |
| 7 | .28 | 37 | +.09 | 25 | .36 | 45 | ..... | ..... | 1.04 | 152 | .27 | 27 | .41 | 38 |
| 8 | 1.31 | 214 | +.04 | 23 | .36 | 39 | ..... | ..... | .90 | 103 | .28 | 28 | .44 | 40 |
| 9 | 1.50 | 260 | −.02 | 20 | .27 | 37 | ..... | ..... | .84 | 87 | .27 | 27 | .92 | 113 |
| 10 | .85 | 119 | .00 | 21 | .21 | 32 | ..... | ..... | .88 | 97 | .22 | 24 | 1.68 | 320 |
| 11 | .58 | 73 | +.26 | 36 | .18 | 30 | ..... | ..... | .92 | 110 | .22 | 24 | 1.29 | 204 |
| 12 | .60 | 76 | .34 | 43 | .18 | 30 | ..... | ..... | .78 | 74 | .22 | 24 | .90 | 109 |
| 13 | .50 | 62 | .28 | 37 | .18 | 30 | ..... | ..... | .80 | 78 | .20 | 23 | .79 | 88 |
| 14 | .61 | 78 | .10 | 25 | .15 | 28 | ..... | ..... | .75 | 68 | .24 | 25 | .77 | 85 |
| 15 | .56 | 70 | .04 | 23 | .12 | 26 | 2.14 | 384 | .65 | 53 | .20 | 23 | .78 | 86 |
| 16 | .49 | 61 | .03 | 22 | .10 | 25 | 1.44 | 192 | .65 | 53 | .51 | 48 | .66 | 66 |
| 17 | .45 | 56 | .02 | 22 | .10 | 25 | 1.29 | 149 | .64 | 52 | .74 | 79 | .60 | 58 |
| 18 | .38 | 47 | .00 | 21 | .32 | 41 | 2.12 | 378 | .64 | 52 | .70 | 72 | .58 | 56 |
| 19 | .26 | 36 | .00 | 21 | .70 | 92 | 1.60 | 237 | .72 | 63 | .64 | 64 | .58 | 56 |
| 20 | .16 | 29 | +.38 | 47 | 1.22 | 194 | 1.36 | 169 | .80 | 78 | .60 | 58 | .50 | 47 |
| 21 | .14 | 27 | .41 | 50 | 1.12 | 172 | 1.26 | 141 | .94 | 117 | .52 | 49 | .51 | 48 |
| 22 | .13 | 27 | .42 | 52 | .83 | 115 | 1.29 | 149 | .70 | 60 | .50 | 47 | .32 | 31 |
| 23 | .36 | 45 | .87 | 123 | .82 | 114 | 1.28 | 146 | .71 | 62 | .46 | 42 | .42 | 39 |
| 24 | .31 | 40 | .53 | 66 | .74 | 99 | 1.66 | 253 | .69 | 59 | .46 | 42 | .43 | 39 |
| 25 | .26 | 36 | .48 | 59 | .65 | 84 | 1.56 | 225 | .66 | 54 | .42 | 39 | .38 | 35 |
| 26 | .18 | 30 | .80 | 110 | .60 | 76 | 1.55 | 222 | .64 | 52 | .62 | 61 | .35 | 33 |
| 27 | .12 | 26 | 1.14 | 176 | .54 | 68 | 1.38 | 174 | .56 | 43 | .67 | 68 | .32 | 31 |
| 28 | .09 | 25 | .78 | 106 | .52 | 65 | 1.26 | 141 | .50 | 37 | .60 | 58 | .31 | 30 |
| 29 | .06 | 23 | .72 | 96 | .52 | 65 | 1.31 | 155 | .48 | 35 | .62 | 61 | .32 | 31 |
| 30 | .04 | 23 | .70 | 92 | .50 | 62 | 1.20 | 124 | .52 | 39 | .78 | 86 | .36 | 34 |
| 31 | .02 | 22 | .62 | 79 | ..... | ..... | ..... | ..... | .56 | 43 | .62 | 61 | ..... | ..... |
| Mean at gaging station | ..... | 56.2 | ..... | 49.0 | ..... | 65.6 | ..... | 202 | ..... | 77.8 | ..... | 44.1 | ..... | 66.7 |
| Mean of Campion ditch | ..... | 5.2 | ..... | 14.4 | ..... | 15.8 | ..... | 0 | ..... | 7.3 | ..... | 12.9 | ..... | 12.5 |
| Total | ..... | 61.4 | ..... | 63.4 | ..... | 81.4 | ..... | 202 | ..... | 85.1 | ..... | 57.0 | ..... | 79.2 |
| David Creek ditch | ..... | [a]6 | ..... | 6 | ..... | [a]7 | ..... | ..... | ..... | 5.5 | ..... | 11.8 | ..... | 9.0 |
| Jett Creek ditch | ..... | [a]1 | ..... | [a]3 | ..... | [a]5 | ..... | ..... | ..... | 3.1 | ..... | 6.1 | ..... | 2.8 |
| Grand Central ditch | ..... | [a]3 | ..... | [a]4 | ..... | [a]5 | ..... | ..... | ..... | 4.3 | ..... | 6.2 | ..... | 9.0 |
| Total | ..... | 10 | ..... | 13 | ..... | 17 | ..... | ..... | ..... | 12.9 | ..... | 24.1 | ..... | 20.8 |
| Natural flow of Nome River | ..... | 51.4 | ..... | 50.4 | ..... | 64.4 | ..... | 202 | ..... | 72.2 | ..... | 32.9 | ..... | 58.4 |
| Run-off per square mile | ..... | 3.43 | ..... | 3.36 | ..... | 4.29 | ..... | 13.5 | ..... | 4.81 | ..... | 2.19 | ..... | 3.89 |
| Run-off, depth in inches | ..... | 3.95 | ..... | 3.87 | ..... | 4.79 | ..... | 8.03 | ..... | 5.54 | ..... | 2.52 | ..... | 4.34 |

[a] Approximate.

NOTE.—Discharges for 1907 were computed from three rating curves, covering June 15 to July 3, July 4 to August 4, and August 5 to September 30. The channel below the gage was scraped out with horses on July 1 to 7 and August 4.

*Natural daily discharge, in second-feet, of Nome River at Miocene intake, 1907.*

| Day. | June. | July. | Aug. | Sept. | Day. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 122 | 26 | 43 | 18 | 378 | 46 | 57 | 41 |
| 2 | ..... | 88 | 26 | 38 | 19 | 237 | 53 | 45 | 43 |
| 3 | ..... | 80 | 25 | 36 | 20 | 169 | 66 | 37 | 40 |
| 4 | ..... | 117 | 24 | 40 | 21 | 141 | 100 | 29 | 35 |
| 5 | ..... | 117 | 23 | 35 | 22 | 149 | 49 | 30 | 22 |
| 6 | ..... | 168 | 23 | 34 | 23 | 146 | 48 | 29 | 18 |
| 7 | ..... | 159 | 19 | 29 | 24 | 253 | 44 | 28 | 31 |
| 8 | ..... | 108 | 22 | 29 | 25 | 225 | 39 | 25 | 30 |
| 9 | ..... | 88 | 22 | 101 | 26 | 222 | 37 | 50 | 30 |
| 10 | ..... | 101 | 19 | 307 | 27 | 174 | 29 | 56 | 28 |
| 11 | ..... | 112 | 19 | 200 | 28 | 141 | 26 | 44 | 27 |
| 12 | ..... | 70 | 19 | 112 | 29 | 155 | 23 | 46 | 26 |
| 13 | ..... | 76 | 18 | 79 | 30 | 124 | 30 | 75 | 18 |
| 14 | ..... | 63 | 20 | 74 | 31 | ..... | 33 | 49 | ..... |
| 15 | 384 | 51 | 16 | 85 | | | | | |
| 16 | 192 | 52 | 34 | 63 | Mean | 202 | 72.2 | 32.9 | 58.4 |
| 17 | 149 | 43 | 63 | 57 | | | | | |

## NOME RIVER AT PIONEER INTAKE AND PIONEER DITCH.

These stations were established to obtain the total discharge of Nome River available for the three ditches. Both were located about one-fourth mile below the diversion dam of the Pioneer ditch.

Gage heights were obtained for only a short period in August, when readings were made by employees of the Pioneer Mining Company.

To obtain the natural flow of the river, the discharge of the Seward ditch at intake and of the Miocene ditch at Clara Creek has been added, and that of the two ditches discharging over Nugget divide subtracted. The run-off per square mile thus obtained is slightly greater than that of the river at the Miocene intake for the same period. The discharge at this station can, therefore, be conservatively estimated at the same rate per square mile as that at the upper station.

*Discharge measurements of Nome River at Pioneer intake and Pioneer ditch, 1907.*

[Elevation, 330 feet.]

NOME RIVER.

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec. ft.* | | *Feet.* | *Sec. ft.* |
| July 9 | 1.89 | 132 | August 20 | 1.39 | 25 |
| July 18 | 1.58 | 58 | August 29 | 1.49 | 46 |
| August 9 | 1.13 | 3 | | | |

PIONEER DITCH.

| | | | | | |
|---|---|---|---|---|---|
| July 18 | 1.22 | 18.7 | August 20 | 1.41 | 24.3 |
| July 24 | 1.35 | 22.2 | August 29 | 1.44 | 25.6 |
| August 9 | 1.19 | 16.8 | | | |

*Daily gage-height and discharge of Nome River and diversions at Pioneer intake, August, 1907.*

[Drainage area, 38 square miles.]

| Day. | Nome River. | | Pioneer ditch. | | Seward ditch. | Miocene ditch. | Total. | Diverted over Nugget divide. | Net total. | Nome River at Miocene intake. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | | | | | | |
| | *Feet.* | *Sec. ft.* | *Feet.* | *Sec. ft.* | *Sec. ft.* | *Sec. ft.* | *Sec. ft.* | *Sec. ft.* | *Sec. ft.* | *Sec. ft.* |
| 21 | 1.40 | 29 | 1.43 | 25.0 | 29.0 | 34.0 | 117 | 17.5 | 100 | 29 |
| 22 | 1.30 | 16 | 1.40 | 24.0 | 26.9 | 34.0 | 101 | 15.5 | 86 | 30 |
| 23 | 1.30 | 16 | 1.42 | 24.7 | 27.9 | 34.0 | 103 | 14.2 | 89 | 29 |
| 24 | 1.25 | 12 | 1.42 | 24.7 | 27.9 | 33.0 | 98 | 16.2 | 82 | 28 |
| 25 | 1.25 | 12 | 1.48 | 26.8 | 29.0 | 34.6 | 103 | 14.9 | 88 | 25 |
| 26 | 1.55 | 52 | 1.48 | 26.8 | 29.0 | 35.2 | 143 | 14.2 | 129 | 50 |
| 27 | 1.60 | 62 | 1.40 | 24.0 | 27.2 | 35.2 | 148 | 14.9 | 133 | 56 |
| 28 | 1.57 | 55 | 1.38 | 23.4 | 27.2 | 35.2 | 140 | 15.6 | 124 | 44 |
| 29 | 1.52 | 47 | 1.30 | 20.8 | 27.9 | 35.2 | 131 | 16.9 | 114 | 46 |
| 30 | 1.75 | 95 | 1.39 | 23.7 | 28.6 | 35.2 | 183 | 14.9 | 168 | 75 |
| 31 | 1.55 | 52 | 1.36 | 22.7 | 28.6 | 35.2 | 139 | 14.9 | 124 | 49 |
| Mean | | 40.7 | | 24.2 | 28.1 | 34.6 | 128 | 15.4 | 112 | 41.9 |
| Run-off per square mile | | | | | | | | | 2.95 | 2.80 |

## BUFFALO CREEK.

Buffalo Creek rises in a high U-shaped valley on the south side of the Kigluaik Mountains, and after a steep descent joins Deep Canyon Creek, forming Nome River. Measurements were made as follows:

*Discharge measurements on Buffalo Creek in 1906.*

[Elevation, 800 feet; drainage area, 4.4 square miles.]

| | Second-feet. |
|---|---|
| June 28 | 18.1 |
| July 6 | 23.3 |
| August 3 | 9.1 |

## DAVID CREEK.

David Creek is the first large tributary of Nome River below the junction of Buffalo and Deep Canyon creeks. Its valley has a northwestward exposure, and holds a considerable amount of snow well into the summer.

The discharge of the David Creek lateral of the Miocene ditch (see p. 33) is equal to that of the creek at the point of diversion at times of low water. This has been compared with the natural flow of Nome River for five such periods, as follows:

*Comparison of flow of David Creek and Nome River at Miocene intake, 1907.*

| Date. | Nome River. | David Creek. | David Creek in per cent of Nome River. |
|---|---|---|---|
| | *Sec. ft.* | *Sec. ft.* | |
| July 25–31 | 31 | 14.3 | 46 |
| August 1–16 | 22 | 10.4 | 47 |
| August 19–25 | 32 | 13.8 | 43 |
| September 3–8 | 34 | 11.9 | 35 |
| September 19–30 | 32 | 11.2 | 35 |

The above table shows that the discharge of David Creek was from 47 to 35 per cent of that of Nome River. The discharge for other periods than those given has therefore been taken as 45 per cent of that of Nome River for July, 40 per cent for August, and 35 per cent for September.

*Monthly discharge of David Creek at Miocene intake, 1907.*

[Drainage area, 4.3 square miles.

| Month. | Discharge in second-feet. | | | Run-off. | |
|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Second-feet per square mile. | Depth in inches. |
| July | 76 | 10.9 | 32.2 | 7.49 | 8.64 |
| August | 30 | 8.9 | 14.2 | 3.30 | 3.80 |
| September | 107 | 8.3 | 20.7 | 4.81 | 5.37 |
| 92 days | 107 | 8.3 | 22.4 | 5.20 | 17.81 |

## DOROTHY CREEK.

Dorothy Creek, which enters Nome River from the southwest, is a short, precipitous stream. It receives water from the Campion ditch, as noted on page 35. The following discharge measurements were made above the outlet of the ditch:

*Discharge measurements on Dorothy Creek in 1906.*

[Elevation, 500 feet; drainage area, 2.7 square miles.]

| | Second-feet. |
|---|---|
| June 16 | 5.1 |
| July 29 | 3.0 |
| August 18 | 2.9 |

## HOBSON CREEK.

Hobson Creek is one of the most interesting and valuable streams in the Nome region. It rises south of Dorothy Creek, flows southward and discharges into Nome River about 18 miles from the seacoast. It is about 4 miles long and very steep. Its only important tributary is Manila Creek, which becomes dry at low water. Hobson Creek is notable for the large limestone springs from which it receives its water. The highest of these springs emerges just above the dam at the Miocene ditch crossing. Above them a trench has been dug across the stream to solid rock, and no flow was intercepted. Between the dam and the mouth of Manila Creek there are many springs, none of them very large, but giving an aggregate discharge nearly equal to that above the Miocene intake.

At low water the Miocene ditch obtains nearly half its water supply from Hobson Creek. Laterals have also been built to the other ditches, that to the Seward lying on the east bank and the Pioneer branch on the west bank.

The water from Hobson Creek is valuable not only on account of its remarkably uniform flow but also on account of its high temperature, which prevents the formation of slush ice during cold nights and makes it possible to run the ditches somewhat longer than they could be with Nome River water alone.

In the opinion of employees of the Miocene Ditch Company the extreme range of the discharge of the upper springs is from 8 to 32 second-feet during the summer season. During the winter they probably run somewhat lower, but always remain open.

*Daily discharge, in second-feet, of Hobson Creek at Miocene intake, 1907.*

[Elevation, 500 feet; drainage area, 2.6 square miles.]

| Day. | June. | July. | Aug. | Sept. | Day. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | 25.5 | 20.4 | 17.7 | 20 | | 22.6 | 14.3 | 19.5 |
| 2 | | 24.9 | 18.7 | 17.3 | 21 | | 23.0 | 15.4 | 19.7 |
| 3 | | 23.8 | 19.1 | 17.3 | 22 | | 21.1 | 14.7 | 18.3 |
| 4 | | 22.7 | 19.3 | 17.7 | 23 | | 22.3 | 14.3 | 22.3 |
| 5 | | 22.7 | 19.2 | 17.3 | 24 | | 23.5 | 16.8 | 20.6 |
| 6 | | 21.1 | 18.9 | 16.9 | 25 | | 22.7 | 18.3 | 19.5 |
| 7 | | 19.6 | 19.4 | 16.5 | 26 | | 24.2 | 17.3 | 19.3 |
| 8 | | 25.8 | 17.3 | 17.9 | 27 | | 21.8 | 17.3 | 17.7 |
| 9 | | 24.5 | 18.1 | 16.6 | 28 | 26.7 | 21.4 | 17.3 | 19.0 |
| 10 | | 22.7 | 18.2 | 18.2 | 29 | 25.8 | 20.2 | 17.7 | 19.3 |
| 11 | | 23.0 | 16.2 | 20.0 | 30 | 25.0 | 20.9 | 17.7 | 19.7 |
| 12 | | 24.0 | 16.7 | 20.5 | 31 | | 21.2 | 17.7 | |
| 13 | | 23.0 | 16.4 | 21.0 | | | | | |
| 14 | | 23.0 | 16.4 | 21.9 | Mean | 25.8 | 22.6 | 17.1 | 19.1 |
| 15 | | 19.7 | 16.3 | 20.3 | Run-off per square mile | 9.92 | 8.69 | 6.58 | 7.35 |
| 16 | | 23.1 | 16.9 | 20.6 | Run-off, depth in inches | 1.11 | 10.02 | 7.59 | 8.20 |
| 17 | | 21.4 | 14.7 | 20.6 | | | | | |
| 18 | | 23.2 | 14.7 | 20.7 | | | | | |
| 19 | | 22.3 | 14.3 | 20.3 | | | | | |

NOTE.—These discharges were obtained by subtracting those of the Miocene ditch above the dam from the flow of the ditch below the dam, and adding the amount spilled from the waste way, as estimated by C. A. McDermith. Some water was being spilled from July 16 to 26 and September 12 to 30.

*Discharge measurements of Hobson Creek below Manila Creek and diversions, 1907.*

[Drainage area, 5.1 square miles.

| Point of measurement. | July 2. | July 9. | July 19. | Aug. 9. | Sept. 28. |
|---|---|---|---|---|---|
| | *Sec. ft.* | *Sec. ft.* | *Sec. ft.* | *Sec. ft.* | *Sec. ft.* |
| Miocene intake | 24.9 | 24.5 | 22.3 | 18.1 | 19.0 |
| Seward lateral | 0.0 | 5.2 | 5.2 | 4.3 | 4.5 |
| Pioneer lateral | 0.0 | 0.0 | 0.0 | 0.0 | 5.8 |
| Hobson Creek below Manila Creek | 25.0 | 21.0 | 17.7 | 10.7 | 5.0 |
| | 49.9 | 50.7 | 45.2 | 33.1 | 34.3 |

## THE MIOCENE DITCH SYSTEM.

### GENERAL DESCRIPTION.

The Miocene ditch system includes 31 miles of main ditch and 31 miles of lateral feeders and distributing ditches, 8 miles of which are under construction. (See Pl. III, *B*, and Pl. V.) This ditch diverts water from upper Glacier Creek, upper Snake River, Nome River and

ROCK CUT AROUND CAPE HORN ON MIOCENE DITCH.

its tributaries, and from the Grand Central River drainage for use on claims along lower Glacier, Dexter, and Anvil creeks.

The first section of this system was built in 1901, from upper Glacier Creek to Snow Gulch, this being the first ditch in Seward Peninsula. In 1902 an extension was made from Ex to Hobson Creek, and in 1903 the ditch was extended to the head of Nome River, these three sections constituting the main line of the system, with a length of 31 miles. The elevation of the intake is 572 feet and that of the lower end 420 feet, giving a fall of 152 feet. This fall varies at different points along the ditch, ranging from 3.17 to 7 feet per mile. There are two siphons, one at Dorothy Creek, 24 inches by 300 feet, which carries about 40 second-feet, and one at Manila Creek, 40 inches by 1,000 feet. Below Willow Creek there is a 1,100-foot flume. The main ditch has an average width of 8 feet above and 10 feet below Hobson Creek, and a capacity of 60 second-feet. The mean flow is about 40 second-feet.

The water is delivered from the end of the ditch on claims along Glacier Creek; on Anvil Creek by a tunnel 1,800 feet long and 4 by 6 feet in cross section, built in 1903 and 1904; and on Dexter Creek by a ditch from Ex around the south side of King Mountain.

The lateral feeders, in order up the ditch, are: (1) From upper Glacier Creek to Ex (this was the upper portion of the first section of the main ditch); (2) from Grouse and Cold creeks to flume; (3) from upper New Eldorado Creek to Buster Creek (it was originally intended to connect this feeder with the main ditch by a siphon across Nome River, but in 1907 it was extended to producing ground on Buster Creek); (4) the David Creek ditch, which empties into Nome River above the intake; (5) the Jett Creek ditch, which takes water from Jett and Copper creeks and carries it over the Nugget divide; (6) the Grand Central ditch, which is under construction (this ditch diverts water from Nugget Creek and will tap the headwaters of Grand Central River).

As a rule water can not be turned into ditches in this region before July 1, as there is too much frost in the ground. In 1906 the water of Hobson Creek was turned into the ditch about June 20 and that of Nome River about June 26, but before July 1 it was turned out frequently to permit repairs. The ditch was also out of use on account of a break from July 8 to 11, inclusive, after which the water ran almost continually. The Nome River water was turned out October 12, and the Hobson Creek water on the morning of the 13th. This season was somewhat longer than usual. In 1907 the Hobson Creek water was turned in on June 27 and that from Nome River on July 3, but the ditch was not run to its full capacity until July 27. All water was turned out on October 3. A break occurred just below Hobson

Creek on September 10 and all water turned out for thirty-three hours; this was practically the only interruption in the flow.

During 1906 two gaging stations were maintained on the ditch—one at Black Point, about 1 mile below the intake, to determine the amount of water diverted from Nome River, and one at the flume, which gives practically the total amount delivered at the mines.

In 1907 three additional stations were established—at Clara Creek, above Hobson Creek, and below Hobson Creek. The difference in discharge at the last two gives the flow of the creek (p. 24). The difference between the flow at any of the other stations and that at the one below it gives the loss by seepage in that portion of the ditch. The Grouse Creek lateral joins the main ditch between Hobson Creek and the flume and sometimes causes an increased discharge at the flume as compared with that at the creek station. Measurements of this lateral are given on page 35. The distances by ditch between stations are as follows: Black Point to Clara Creek, 7.1 miles; Clara Creek to Hobson Creek, 4.9 miles; Hobson Creek to the flume, 4.2 miles; the flume to the Ex, 9.5 miles. Measurements at the Ex are given on page 30. The flow of the Glacier Creek lateral about equals the seepage below the flume.

The results of measurements at the above-named stations are given in the following pages. All the gages were read by employees of the Miocene Ditch Company from two to four times a day. Gage readings taken after September 30 were unreliable, on account of the slush ice that was running, and the discharge for the last few days in September may be slightly too large, for the same reason.

*Discharge measurements of Miocene ditch at Black Point, 1906–7.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec. ft.* | 1907. | *Feet.* | *Sec. ft.* |
| July 7 | 0.80 | 31.8 | July 4 | 0.51 | 21.8 |
| July 13 | .89 | 34.1 | July 10 | .57 | 24.0 |
| July 21 | .71 | 27.5 | July 17 | .79 | 29.6 |
| July 27 | .68 | 25.7 | August 2 | .96 | 36.4 |
| July 29 | .46 | 20.6 | August 6 | .62 | 25.1 |
| August 2 | .39 | 18.1 | August 16 | .91 | 33.5 |
| August 11 | 1.20 | 44.7 | Do | 1.13 | 42.5 |
| August 23 | 1.30 | 48.3 | | | |
| September 11 | .85 | 30.7 | | | |
| September 25 | 1.10 | 38.2 | | | |

*Daily gage height and discharge of Miocene ditch at Black Point, 1906–7.*

| Day. | 1906. | | | | | | 1907. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July. | | August. | | September. | | July. | | August. | | September. | |
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.70 | 27 | 0.40 | 18.8 | 1.20 | 43.5 | ..... | ..... | 1.05 | 38.8 | 1.15 | 42.2 |
| 2 | .70 | 27 | .38 | 18.5 | 1.20 | 43.5 | ..... | ..... | .98 | 36.5 | 1.15 | 42.2 |
| 3 | .60 | 24 | .35 | 18 | 1.20 | 43.5 | 0.52 | 22.3 | .91 | 34.2 | 1.15 | 42.2 |
| 4 | .85 | 31.5 | .34 | 17.8 | 1.20 | 43.5 | .50 | 21.7 | .85 | 32.2 | 1.15 | 42.2 |
| 5 | .95 | 34.8 | .33 | 17.7 | 1.20 | 43.5 | .50 | 21.7 | .80 | 30.7 | 1.15 | 42.2 |
| 6 | .88 | 32.4 | .34 | 17.8 | 1.20 | 43.5 | .45 | 20.4 | .68 | 27.0 | 1.15 | 42.2 |
| 7 | .85 | 31.5 | .52 | 21.6 | 1.17 | 42.4 | .40 | 19.2 | .61 | 24.9 | 1.04 | 38.4 |
| 8 | ..... | 0 | .48 | 20.6 | 1.04 | 37.9 | .48 | 21.1 | .64 | 25.8 | 1.08 | 39.8 |
| 9 | ..... | 0 | .37 | 18.3 | 1.00 | 36.5 | .48 | 21.1 | .61 | 24.9 | 1.10 | 40.5 |
| 10 | ..... | 0 | .40 | 18.8 | .98 | 35.8 | .50 | 21.7 | .52 | 22.3 | .80 | 30.7 |
| 11 | .50 | 21 | .84 | 30.3 | .82 | 30.6 | .50 | 21.7 | .52 | 22.3 | .48 | 21.1 |
| 12 | 1.00 | 36.5 | .82 | 30.6 | .80 | 30 | .50 | 21.7 | .52 | 22.3 | .98 | 36.5 |
| 13 | 1.00 | 36.5 | .96 | 35.1 | .80 | 30 | .50 | 21.7 | .50 | 21.7 | 1.15 | 42.2 |
| 14 | 1.00 | 36.5 | .60 | 24 | .76 | 28.8 | .50 | 21.7 | .55 | 23.1 | 1.08 | 39.8 |
| 15 | 1.20 | 43.5 | .50 | 21 | .72 | 27.6 | .80 | 30.7 | .45 | 20.4 | 1.00 | 37.1 |
| 16 | 1.10 | 40 | .50 | 21 | .66 | 25.8 | .80 | 30.7 | .90 | 33.8 | 1.00 | 37.1 |
| 17 | 1.10 | 40 | .45 | 19.9 | .64 | 25.2 | .80 | 30.7 | 1.15 | 42.2 | 1.00 | 37.1 |
| 18 | 1.10 | 40 | .39 | 18.6 | .78 | 29.4 | .80 | 30.7 | 1.15 | 42.2 | 1.00 | 37.1 |
| 19 | .92 | 33.7 | .46 | 20.1 | .80 | 30 | .80 | 30.7 | 1.15 | 42.2 | 1.08 | 39.8 |
| 20 | .70 | 27 | .86 | 31.8 | .58 | 23.4 | .80 | 30.7 | 1.16 | 42.6 | 1.15 | 42.2 |
| 21 | .70 | 27 | 1.12 | 40.7 | .69 | 26.7 | .80 | 30.7 | 1.16 | 42.6 | 1.08 | 39.8 |
| 22 | .62 | 24.6 | 1.03 | 37.6 | .92 | 33.7 | .80 | 30.7 | 1.16 | 42.6 | 1.15 | 42.2 |
| 23 | .85 | 31.5 | 1.17 | 42.4 | 1.00 | 36.5 | .80 | 30.7 | 1.10 | 40.5 | 1.15 | 42.2 |
| 24 | .95 | 34.8 | 1.19 | 43.2 | .96 | 35.1 | .80 | 30.7 | 1.08 | 39.8 | 1.06 | 39.1 |
| 25 | .92 | 33.7 | 1.20 | 43.5 | 1.05 | 38.2 | .85 | 32.2 | 1.02 | 37.7 | 1.00 | 37.1 |
| 26 | .75 | 28.5 | 1.17 | 42.4 | 1.06 | 38.6 | .86 | 32.6 | 1.15 | 42.2 | 1.04 | 38.4 |
| 27 | .62 | 24.6 | 1.16 | 42.1 | 1.22 | 44.2 | 1.00 | 37.1 | 1.16 | 42.6 | .98 | 36.5 |
| 28 | .54 | 22.2 | 1.20 | 43.5 | 1.20 | 43.5 | .94 | 35.1 | 1.16 | 42.6 | .94 | 35.1 |
| 29 | .50 | 21 | 1.20 | 43.5 | 1.20 | 43.5 | .94 | 35.1 | 1.16 | 42.6 | 1.02 | 37.7 |
| 30 | .45 | 19.9 | 1.20 | 43.5 | 1.20 | 43.5 | .96 | 35.8 | 1.15 | 42.2 | 1.12 | 41.2 |
| 31 | .42 | 19.2 | 1.20 | 43.5 | ..... | ..... | 1.10 | 40.5 | 1.15 | 42.2 | ..... | ..... |
| Mean | ..... | 27.4 | ..... | 29.2 | ..... | 35.9 | ..... | 28.0 | ..... | 34.4 | ..... | 38.7 |

*Discharge measurements of Miocene ditch at Clara Creek, 1907.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| July 9 | 0.50 | 18.2 | August 20 | 0.91 | 35.2 |
| July 18 | .79 | 27.7 | August 29 | .92 | 34.7 |
| August 9 | .60 | 21.1 | September 27 | .88 | 34.0 |

*Daily gage height and discharge of Miocene ditch at Clara Creek, 1907.*

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | 0.89 | 33.5 | 0.92 | 35.2 | 18 | 0.82 | 30.0 | 0.91 | 34.6 | 0.91 | 34.6 |
| 2 | ..... | ..... | .85 | 31.5 | .92 | 35.2 | 19 | .79 | 28.6 | .90 | 34.0 | .92 | 35.2 |
| 3 | ..... | [a] 18.0 | .84 | 31.0 | .92 | 35.2 | 20 | .79 | 28.6 | .91 | 34.6 | .85 | 31.5 |
| 4 | ..... | [a] 19.0 | .80 | 29.0 | .92 | 35.2 | 21 | .81 | 29.5 | .90 | 34.0 | .95 | 37.0 |
| 5 | ..... | [a] 19.0 | .78 | 28.1 | .92 | 35.2 | 22 | .82 | 30.0 | .90 | 34.0 | .88 | 33.0 |
| 6 | ..... | [a] 19.0 | .66 | 23.1 | .91 | 34.6 | 23 | .80 | 29.0 | .90 | 34.0 | .88 | 33.0 |
| 7 | 0.52 | 18.8 | .60 | 21.0 | .89 | 33.5 | 24 | .80 | 29.0 | .88 | 33.0 | .92 | 35.2 |
| 8 | .55 | 19.6 | .58 | 20.4 | .88 | 33.0 | 25 | .80 | 29.0 | .91 | 34.6 | .90 | 34.0 |
| 9 | .50 | 18.2 | .55 | 19.6 | .92 | 35.2 | 26 | .82 | 30.0 | .92 | 35.2 | .92 | 35.2 |
| 10 | .54 | 19.3 | .52 | 18.8 | .69 | 24.2 | 27 | .88 | 33.0 | .92 | 35.2 | .88 | 33.0 |
| 11 | .56 | 19.9 | .50 | 18.2 | .70 | 24.5 | 28 | .88 | 33.0 | .92 | 35.2 | .84 | 31.0 |
| 12 | .46 | 17.2 | .50 | 18.2 | .88 | 33.0 | 29 | .83 | 30.5 | .92 | 35.2 | .88 | 33.0 |
| 13 | .50 | 18.2 | .48 | 17.7 | .95 | 37.0 | 30 | .89 | 33.5 | .92 | 35.2 | .88 | 33.0 |
| 14 | .51 | 18.5 | .52 | 18.8 | .95 | 37.0 | 31 | .92 | 35.2 | .92 | 35.2 | ..... | ..... |
| 15 | .71 | 25.0 | .48 | 17.7 | .94 | 36.4 | | | | | | | |
| 16 | .82 | 30.0 | .72 | 25.4 | .91 | 34.6 | Mean | ..... | 25.4 | ..... | 28.7 | ..... | 33.7 |
| 17 | .75 | 26.8 | .92 | 35.2 | .91 | 34.6 | | | | | | | |

[a] Estimated from Black Point records.

*Discharge measurements of Miocene ditch above Hobson Creek, 1907.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| July 9 | 0.88 | 17.6 | August 29 | 1.38 | 35.4 |
| July 19 | 1.25 | 25.7 | September 27 | 1.36 | 31.7 |
| August 9 | .98 | 18.8 | September 28 | 1.30 | 31.8 |

*Daily gage height and discharge of Miocene ditch above Hobson Creek, 1907.*

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | 1.37 | 33.1 | 1.38 | 33.5 | 18 | 1.20 | 27.0 | 1.38 | 33.5 | 1.37 | 33.1 |
| 2 | ..... | ..... | 1.31 | 31.0 | 1.38 | 33.5 | 19 | 1.20 | 27.0 | 1.38 | 33.5 | 1.38 | 33.5 |
| 3 | 0.80 | 14.7 | 1.30 | 30.6 | 1.38 | 33.5 | 20 | 1.16 | 25.6 | 1.38 | 33.5 | 1.35 | 32.4 |
| 4 | .90 | 17.3 | 1.20 | 27.0 | 1.38 | 33.5 | 21 | 1.21 | 27.4 | 1.38 | 33.5 | 1.39 | 33.8 |
| 5 | .90 | 17.3 | 1.18 | 26.3 | 1.38 | 33.5 | 22 | 1.21 | 27.4 | 1.38 | 33.5 | 1.39 | 33.8 |
| 6 | .90 | 17.3 | 1.04 | 21.5 | 1.38 | 33.5 | 23 | 1.23 | 28.1 | 1.37 | 33.1 | 1.29 | 30.2 |
| 7 | .93 | 18.1 | .97 | 19.3 | 1.35 | 32.4 | 24 | 1.24 | 28.4 | 1.29 | 30.2 | 1.39 | 33.8 |
| 8 | .77 | 13.9 | .95 | 18.7 | 1.31 | 31.0 | 25 | 1.22 | 27.7 | 1.30 | 30.6 | 1.39 | 33.8 |
| 9 | .89 | 17.0 | .99 | 19.9 | 1.39 | 33.8 | 26 | 1.22 | 27.7 | 1.38 | 33.5 | 1.39 | 33.8 |
| 10 | .90 | 17.3 | .90 | 17.3 | 1.42 | 34.9 | 27 | 1.33 | 31.7 | 1.38 | 33.5 | 1.35 | 32.4 |
| 11 | .89 | 17.0 | .88 | 16.8 | ..... | 0 | 28 | 1.33 | 31.7 | 1.38 | 33.5 | 1.27 | 29.5 |
| 12 | .85 | 16.0 | .86 | 16.3 | 1.34 | 32.0 | 29 | 1.28 | 29.9 | 1.38 | 33.5 | 1.30 | 30.0 |
| 13 | .89 | 17.0 | .84 | 15.7 | 1.40 | 34.2 | 30 | 1.27 | 29.5 | 1.38 | 33.5 | 1.35 | 32.4 |
| 14 | .89 | 17.0 | .92 | 17.9 | 1.40 | 34.2 | 31 | 1.38 | 33.5 | 1.38 | 33.5 | ..... | ..... |
| 15 | 1.22 | 27.7 | .80 | 14.7 | 1.37 | 33.1 | | | | | | | |
| 16 | 1.17 | 25.9 | 1.02 | 20.8 | 1.36 | 32.8 | Mean | ..... | 23.6 | ..... | 27.4 | ..... | 31.8 |
| 17 | 1.21 | 27.4 | 1.39 | 33.8 | 1.36 | 32.8 | | | | | | | |

*Discharge measurements of Miocene ditch below Hobson Creek, 1907.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| July 2 | 1.60 | 24.8 | July 24 | 2.38 | 49.4 |
| July 9 | 2.08 | 39.1 | September 27 | 2.38 | 52.0 |
| July 19 | 2.30 | 46.8 | | | |

*Daily gage height and discharge of Miocene ditch below Hobson Creek, 1907.*

| Day. | June. | | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.63 | 25.5 | 2.46 | 53.5 | 2.40 | 51.2 |
| 2 | | | 1.60 | 24.9 | 2.36 | 49.7 | 2.39 | 50.8 |
| 3 | | | 1.74 | 28.3 | 2.36 | 49.7 | 2.39 | 50.8 |
| 4 | | | 2.10 | 40.0 | 2.27 | 46.3 | 2.40 | 51.2 |
| 5 | | | 2.10 | 40.0 | 2.25 | 45.5 | 2.39 | 50.8 |
| 6 | | | 2.05 | 38.4 | 2.11 | 40.4 | 2.38 | 50.4 |
| 7 | | | 2.03 | 37.7 | 2.06 | 38.7 | 2.34 | 48.9 |
| 8 | | | 2.09 | 39.7 | 1.98 | 36.0 | 2.34 | 48.9 |
| 9 | | | 2.14 | 41.5 | 2.04 | 38.0 | 2.38 | 50.4 |
| 10 | | | 2.10 | 40.0 | 1.95 | 35.5 | 2.45 | 53.1 |
| 11 | | | 2.10 | 40.0 | 1.89 | 33.0 | | 0 |
| 12 | | | 2.10 | 40.0 | 1.89 | 33.0 | 2.33 | 48.5 |
| 13 | | | 2.10 | 40.0 | 1.86 | 32.1 | 2.40 | 51.2 |
| 14 | | | 2.10 | 40.0 | 1.93 | 34.3 | 2.37 | 50.1 |
| 15 | | | 2.30 | 47.4 | 1.83 | 31.0 | 2.30 | 47.4 |
| 16 | | | 2.29 | 47.0 | 2.03 | 37.7 | 2.30 | 47.4 |
| 17 | | | 2.31 | 47.8 | 2.33 | 48.5 | 2.30 | 47.4 |
| 18 | | | 2.32 | 48.2 | 2.32 | 48.2 | 2.31 | 47.8 |
| 19 | | | 2.31 | 47.8 | 2.31 | 47.8 | 2.31 | 47.8 |
| 20 | | | 2.30 | 47.4 | 2.31 | 47.8 | 2.34 | 48.9 |
| 21 | | | 2.30 | 47.4 | 2.34 | 48.9 | 2.33 | 48.5 |
| 22 | | | 2.33 | 48.5 | 2.32 | 48.2 | 2.32 | 48.2 |
| 23 | | | 2.38 | 50.4 | 2.30 | 47.4 | 2.33 | 48.5 |
| 24 | | | 2.38 | 50.4 | 2.29 | 47.0 | 2.38 | 50.4 |
| 25 | | | 2.34 | 48.9 | 2.34 | 48.9 | 2.35 | 49.3 |
| 26 | | | 2.38 | 50.4 | 2.39 | 50.8 | 2.37 | 50.1 |
| 27 | | | 2.46 | 53.5 | 2.39 | 50.8 | 2.37 | 50.1 |
| 28 | 1.68 | 26.7 | 2.45 | 53.1 | 2.39 | 50.8 | 2.33 | 48.5 |
| 29 | 1.64 | 25.8 | 2.37 | 50.1 | 2.40 | 51.2 | 2.35 | 49.3 |
| 30 | 1.60 | 25.0 | 2.38 | 50.4 | 2.40 | 51.2 | 2.37 | 50.1 |
| 31 | | | 2.49 | 54.7 | 2.40 | 51.2 | | |
| Mean | | 25.8 | | 43.8 | | 45.3 | | 47.9 |

*Discharge measurements of Miocene ditch at flume, 1906–7.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-ft.* | 1907. | *Feet.* | *Sec.-ft.* |
| July 4 | 0.95 | 29.8 | July 2 | 1.58 | 36 |
| July 27 | 1.08 | 36.5 | July 3 | 1.51 | 32 |
| August 2 | .81 | 28.3 | July 19 | 1.99 | 50 |
| September 11 | 1.50 | 43.9 | July 23 | 2.09 | 55 |
| September 25 | 1.85 | 58.2 | August 10 | 1.63 | 33 |
| September 26 | 1.65 | 48.5 | August 29 | 2.05 | 51 |
| | | | September 28 | 2.02 | 50 |

*Daily gage height and discharge of Miocene ditch at flume, 1906–7.*

| Day. | 1906. | | | | | | 1907. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July. | | August. | | September. | | July. | | August. | | September. | |
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.98 | 31.6 | 0.82 | 27.2 | 1.71 | 51.5 | 1.56 | 33.5 | 2.05 | 52.0 | 2.02 | 50.8 |
| 2 | .95 | 30.8 | .81 | 27 | 1.71 | 51.5 | 1.56 | 33.5 | 2.00 | 50.0 | 2.00 | 50.0 |
| 3 | .92 | 29.9 | .84 | 27.8 | 1.70 | 51.2 | 1.56 | 33.5 | 1.92 | 46.8 | 2.00 | 50.0 |
| 4 | 1.00 | 32.1 | .89 | 29.1 | 1.70 | 51.2 | 1.74 | 39.6 | 1.86 | 44.4 | 2.00 | 50.0 |
| 5 | 1.08 | 34.3 | .90 | 29.4 | 1.70 | 51.2 | 1.75 | 40.0 | 1.82 | 42.8 | 2.00 | 50.0 |
| 6 | 1.09 | 34.5 | .91 | 29.7 | 1.69 | 50.9 | 1.75 | 40.0 | 1.78 | 41.2 | 2.00 | 50.0 |
| 7 | 1.12 | 35.3 | .93 | 30.2 | 1.66 | 50.1 | 1.70 | 38.0 | 1.70 | 38.0 | 1.99 | 49.6 |
| 8 | (*a*) | 0 | .98 | 31.6 | 1.68 | 50.6 | 1.77 | 40.8 | 1.68 | 37.3 | 1.98 | 49.2 |
| 9 | (*a*) | 0 | .90 | 29.4 | 1.63 | 49.2 | 1.80 | 42.0 | 1.69 | 37.7 | 2.04 | 51.6 |
| 10 | (*a*) | 0 | .88 | 28.9 | 1.54 | 46.7 | 1.86 | 44.4 | 1.63 | 35.6 | 2.10 | 54.0 |
| 11 | .79 | 26.4 | 1.01 | 32.4 | 1.49 | 45.3 | 1.77 | 41.0 | 1.58 | 34.0 | (*a*) | 0 |
| 12 | 1.10 | 34.8 | 1.13 | 35.6 | 1.46 | 44.5 | 1.80 | 42.0 | 1.56 | 33.5 | 1.98 | 49.2 |
| 13 | 1.26 | 39.1 | 1.23 | 38.3 | 1.45 | 44.2 | 1.85 | 44.0 | 1.54 | 32.9 | 2.02 | 50.8 |
| 14 | 1.29 | 39.9 | 1.02 | 32.6 | 1.41 | 43.2 | 1.85 | 44.0 | 1.58 | 34.0 | 2.12 | 54.8 |
| 15 | 1.28 | 39.7 | .94 | 30.5 | 1.40 | 42.9 | 1.92 | 46.8 | 1.50 | 31.8 | 2.10 | 54.0 |
| 16 | 1.39 | 42.6 | .92 | 29.9 | 1.34 | 41.3 | 1.80 | 42.0 | 1.71 | 38.4 | 2.10 | 54.0 |
| 17 | 1.35 | 41.6 | .91 | 29.7 | 1.31 | 40.5 | 1.95 | 48.0 | 1.96 | 48.4 | 2.10 | 54.0 |
| 18 | 1.35 | 41.6 | .87 | 28.6 | 1.47 | 44.8 | 1.95 | 48.0 | 1.95 | 48.0 | 2.11 | 54.4 |
| 19 | 1.28 | 39.7 | .86 | 28.3 | 1.48 | 45.1 | 1.95 | 48.0 | 1.92 | 46.8 | 2.12 | 54.8 |
| 20 | 1.19 | 37.2 | 1.10 | 34.8 | 1.52 | 46.2 | 1.95 | 48.0 | 1.94 | 47.6 | 2.10 | 54.0 |
| 21 | 1.16 | 36.4 | 1.29 | 39.9 | 1.58 | 47.8 | 2.00 | 50.0 | 1.95 | 48.0 | 2.13 | 55.2 |
| 22 | 1.11 | 35.1 | 1.28 | 39.7 | 1.65 | 49.8 | 2.00 | 50.0 | 1.93 | 47.2 | 2.08 | 53.2 |
| 23 | 1.19 | 37.2 | 1.32 | 40.7 | 1.61 | 48.7 | 2.02 | 50.8 | 1.92 | 46.8 | 2.04 | 51.6 |
| 24 | 1.09 | 34.5 | 1.40 | 42.9 | 1.60 | 48.4 | 1.99 | 49.6 | 1.92 | 46.8 | 2.09 | 53.6 |
| 25 | 1.26 | 39.1 | 1.44 | 44 | 1.71 | 51.5 | 2.01 | 50.4 | 1.95 | 48.0 | 2.09 | 53.6 |
| 26 | 1.17 | 36.7 | 1.55 | 47 | 1.63 | 49.2 | 2.05 | 52.0 | 2.00 | 50.0 | 2.08 | 53.2 |
| 27 | 1.07 | 34 | 1.34 | 41.3 | 1.75 | 52.6 | 2.08 | 53.2 | 2.04 | 51.6 | 2.08 | 53.2 |
| 28 | .98 | 31.6 | 1.46 | 44.5 | 1.76 | 52.9 | 2.06 | 52.4 | 2.01 | 50.4 | 2.03 | 51.2 |
| 29 | .95 | 30.8 | 1.51 | 45.9 | 1.79 | 53.7 | 2.04 | 51.6 | 2.04 | 51.6 | 2.03 | 51.2 |
| 30 | .91 | 29.7 | 1.56 | 47.3 | 1.80 | 54 | 2.00 | 50.0 | 2.06 | 52.4 | 2.04 | 51.6 |
| 31 | .88 | 28.9 | 1.50 | 45.6 | ..... | ..... | 2.03 | 51.2 | 2.03 | 51.2 | ..... | ..... |
| Mean | ..... | [*b*] 31.8 | ..... | 35.2 | ..... | 48.4 | ..... | 45.1 | ..... | 44.0 | ..... | 50.4 |

[*a*] Ditch broken by heavy rains.

[*b*] For 28 days, 35.2 second-feet.

NOTE.—About 28 second-feet turned in June 28, 1907.

*Discharge measurements of Miocene ditch below the Ex, 1907.*

| Date. | Glacier branch. | Dexter branch. | Total. |
|---|---|---|---|
| | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* |
| June 26 | 8.8 | 0. | 8.8 |
| July 6 | 27.6 | 16.0 | 43.6 |
| July 19 | 31.5 | 14.0 | 45.5 |
| September 4 | 34.3 | 13.0 | 47.3 |

JETT CREEK DITCH.

The Jett Creek ditch was constructed during 1906 to divert water from Jett and Copper creeks over the Nugget divide. In 1906 the water was turned in from Copper Creek July 20 and from Jett Creek August 18, and was turned out September 25. The ditch carries the total flow of these creeks above the intake up to a maximum of about 10 second-feet. In 1907 a gage was established below Copper Creek and read by A. D. Jett.

*Discharge measurements on Jett Creek ditch at outlet, 1906–7.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-ft.* | 1906. | *Feet.* | *Sec.-ft.* |
| July 21 | | 2.4 | September 14 | | 3.9 |
| August 11 | | .8 | 1907. | | |
| August 29 | | 4.6 | July 31 | 1.59 | 8.1 |
| August 31 | | 7.3 | Do | 1.38 | 5.3 |
| September 2 | | 9.2 | Do | 1.21 | 3.6 |
| September 7 | | 7.2 | Do | .75 | 0.0 |
| September 10 | | 5.3 | | | |

*Daily gage height and discharge of Jett Creek ditch, 1907.*

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.59 | 8.1 | 1.50 | 6.9 | 18 | 1.18 | 3.2 | 1.60 | 8.2 | | |
| 2 | | | 1.50 | 6.9 | 1.50 | 6.9 | 19 | 1.19 | 3.3 | 1.60 | 8.2 | | |
| 3 | | | 1.45 | 6.2 | 1.50 | 6.9 | 20 | 1.30 | 4.4 | 1.55 | 7.6 | | |
| 4 | | | 1.40 | 5.6 | 1.45 | 6.2 | 21 | 1.42 | 5.9 | 1.50 | 6.9 | | |
| 5 | | | 1.35 | 5.0 | 1.45 | 6.2 | 22 | 1.22 | 3.6 | 1.45 | 6.2 | | |
| 6 | | | 1.33 | 4.8 | 1.45 | 6.2 | 23 | 1.32 | 4.6 | 1.45 | 6.2 | | |
| 7 | | | 1.33 | 4.8 | 1.45 | 6.2 | 24 | 1.38 | 5.4 | 1.50 | 6.9 | | |
| 8 | | | 1.33 | 4.8 | 1.50 | 6.9 | 25 | 1.40 | 5.6 | 1.50 | 6.9 | | |
| 9 | | | 1.25 | 3.9 | 1.60 | 8.2 | 26 | 1.45 | 6.2 | 1.45 | 6.2 | | |
| 10 | | | 1.25 | 3.9 | | 0 | 27 | 1.45 | 6.2 | 1.50 | 6.9 | | |
| 11 | | | 1.25 | 3.9 | | 0 | 28 | 1.42 | 5.9 | 1.55 | 7.6 | | |
| 12 | 1.15 | 3.0 | 1.25 | 3.9 | 1.60 | 8.2 | 29 | 1.45 | 6.2 | 1.55 | 7.6 | | |
| 13 | 1.35 | 5.0 | 1.30 | 4.4 | 1.60 | 8.2 | 30 | 1.50 | 6.9 | 1.50 | 6.9 | | |
| 14 | 1.32 | 4.6 | 1.30 | 4.4 | 1.60 | 8.2 | 31 | 1.59 | 8.1 | 1.50 | 6.9 | | |
| 15 | 1.15 | 3.0 | 1.30 | 4.4 | | | | | | | | | |
| 16 | 1.20 | 3.4 | 1.55 | 7.6 | | | Mean | | 4.9 | | 6.1 | | 6.1 |
| 17 | 1.15 | 3.0 | 1.50 | 6.9 | | | | | | | | | |

GRAND CENTRAL DITCH.

The completed portion of the Grand Central ditch diverted water from Nugget Creek at an elevation of 785 feet from June 27 to September 29, 1906, and from July 9 to October 2, 1907. In 1907 a gage was installed just below Nugget Creek and read by A. D. Jett. The entire flow of the creek was diverted except on September 11 and 12 and possibly a few other days of high water. For measurements during 1906 see page 50.

*Discharge measurements of Grand Central ditch, 1907.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| July 9 | 1.39 | 5.4 | July 9 | 1.18 | 1.27 |
| Do | 1.28 | 3.7 | Do | 1.47 | 6.6 |

*Daily gage height and discharge of Grand Central ditch, 1907.*

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | 1.34 | 4.4 | 1.50 | 8.0 | 18 | 1.40 | 5.6 | 1.55 | 9.3 | 1.70 | 13.4 |
| 2 | ..... | ..... | 1.34 | 4.4 | 1.50 | 8.0 | 19 | 1.46 | 7.0 | 1.55 | 9.3 | 1.60 | 10.6 |
| 3 | ..... | ..... | 1.32 | 4.0 | 1.45 | 6.8 | 20 | 1.48 | 7.5 | 1.60 | 10.6 | 1.60 | 10.6 |
| 4 | ..... | ..... | 1.32 | 4.0 | 1.45 | 6.8 | 21 | 1.65 | 12.0 | 1.60 | 10.6 | 1.60 | 10.6 |
| 5 | ..... | ..... | 1.32 | 4.0 | 1.45 | 6.8 | 22 | 1.47 | 7.3 | 1.55 | 9.3 | 1.55 | 9.3 |
| 6 | ..... | ..... | 1.30 | 3.6 | 1.45 | 6.8 | 23 | 1.48 | 7.5 | 1.50 | 8.0 | 1.55 | 9.3 |
| 7 | ..... | ..... | 1.30 | 3.6 | 1.45 | 6.8 | 24 | 1.46 | 7.0 | 1.55 | 9.3 | 1.55 | 9.3 |
| 8 | ..... | ..... | 1.28 | 3.3 | 1.50 | 8.0 | 25 | 1.40 | 5.6 | 1.50 | 8.0 | 1.50 | 8.0 |
| 9 | 1.45 | 6.8 | 1.28 | 3.3 | 1.60 | 10.6 | 26 | 1.38 | 5.2 | 1.50 | 8.0 | 1.50 | 8.0 |
| 10 | 1.34 | 4.4 | 1.25 | 2.8 | 1.70 | 13.4 | 27 | 1.36 | 4.8 | 1.50 | 8.0 | ..... | 8.0 |
| 11 | 1.34 | 4.4 | 1.25 | 2.8 | ..... | 0 | 28 | 1.33 | 4.2 | 1.50 | 8.0 | ..... | 8.0 |
| 12 | 1.38 | 5.2 | 1.28 | 3.3 | ..... | 0 | 29 | 1.32 | 4.0 | 1.55 | 9.3 | ..... | 8.0 |
| 13 | 1.38 | 5.2 | 1.27 | 3.1 | 1.70 | 13.4 | 30 | 1.32 | 4.0 | 1.50 | 8.0 | ..... | 8.0 |
| 14 | 1.45 | 6.8 | 1.30 | 3.6 | 1.70 | 13.4 | 31 | 1.34 | 4.4 | 1.50 | 8.0 | ..... | ..... |
| 15 | 1.35 | 4.6 | 1.30 | 3.6 | 1.70 | 13.4 | | | | | | | |
| 16 | 1.35 | 4.6 | 1.50 | 8.0 | 1.70 | 13.4 | Mean | ..... | 5.7 | ..... | 6.2 | ..... | 9.0 |
| 17 | 1.31 | 3.8 | 1.50 | 8.0 | 1.70 | 13.4 | | | | | | | |

DAVID CREEK DITCH.

David Creek enters Nome River from the east a short distance below the intake of the Miocene ditch. It has a well-sustained flow which is diverted at an elevation of about 590 feet by a ditch that discharges into Nome River just above the Miocene intake. In 1906 the water was running in this ditch before gagings were made on Nome River. Except during extreme high water, it carried the entire flow of David Creek up to its capacity of about 14 second-feet. When the ditch was cleaned out in 1907 it was enlarged from 4 feet to 5 feet on the bottom, increasing its capacity to nearly 20 second-feet. The gage was read by employees of the Miocene Ditch Company during August, 1906, and July to September, 1907.

*Discharge measurements of David Creek ditch, 1906–7.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-ft.* | 1906. | *Feet.* | *Sec.-ft.* |
| July 3 | ..... | 3.5 | August 29 | 0.81 | 13.7 |
| July 29 | ..... | 6.4 | Do | .68 | 11.4 |
| August 3 | ..... | 4.4 | | | |
| August 23 | 0.51 | 7.9 | 1907. | | |
| August 29 | .41 | 5.4 | July 17 | .50 | 8.9 |
| Do | .49 | 7.6 | July 25 | .79 | 13.0 |
| Do | .63 | 10.1 | Do | .83 | 13.7 |
| Do | .78 | 13.7 | August 4 | .69 | 11.5 |

*Daily gage height and discharge of David Creek ditch, 1906–7.*

[Drainage area at point of diversion, 4.3 square miles.]

| Day. | 1906. | | 1907. | | | | | |
|---|---|---|---|---|---|---|---|---|
| | August. | | July. | | August. | | September. | |
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | | | 0.75 | 12.4 | 0.70 | 11.6 |
| 2 | | | | | .70 | 11.6 | .65 | 10.9 |
| 3 | | | | | .80 | 13.2 | .80 | 13.2 |
| 4 | 0.35 | 4.4 | | | .69 | 11.5 | .80 | 13.2 |
| 5 | .35 | 4.4 | | | .67 | 11.2 | .72 | 11.9 |
| 6 | .35 | 4.4 | | | .62 | 10.5 | .70 | 11.6 |
| 7 | .42 | 5.8 | | | .60 | 10.2 | .68 | 11.3 |
| 8 | .38 | 5.0 | | | .56 | 9.6 | .60 | 10.2 |
| 9 | .37 | 4.8 | | | .56 | 9.6 | .60 | 10.2 |
| 10 | .37 | 4.8 | | | .52 | 9.1 | .50 | 8.9 |
| 11 | .38 | 5.0 | | | .52 | 9.1 | .55 | 9.5 |
| 12 | .40 | 5.4 | | | .52 | 9.1 | | 0 |
| 13 | .38 | 5.0 | | | .52 | 9.1 | | 0 |
| 14 | .35 | 4.4 | | | .50 | 8.9 | | 0 |
| 15 | .34 | 4.3 | | | .50 | 8.9 | | 0 |
| 16 | .33 | 4.1 | | | .80 | 13.2 | | 0 |
| 17 | .39 | 5.2 | 0.50 | 8.9 | .82 | 13.5 | | 0 |
| 18 | .31 | 3.7 | .52 | 9.1 | .80 | 13.2 | .90 | 14.9 |
| 19 | .29 | 3.3 | .50 | 8.9 | .90 | 14.9 | .99 | 16.5 |
| 20 | .40 | 5.4 | .60 | 10.2 | .90 | 14.9 | .85 | 14.0 |
| 21 | .38 | 5.0 | .60 | 10.2 | .95 | 15.8 | .85 | 14.0 |
| 22 | .50 | 7.5 | .60 | 10.2 | .95 | 15.8 | .73 | 12.1 |
| 23 | .52 | 7.9 | .80 | 13.2 | .72 | 11.9 | .68 | 11.3 |
| 24 | .48 | 7.1 | .80 | 13.2 | .70 | 11.6 | | 10.6 |
| 25 | .54 | 8.3 | .80 | 13.2 | .72 | 11.9 | .58 | 9.9 |
| 26 | .77 | 13.2 | .80 | 13.2 | .72 | 11.9 | .57 | 9.8 |
| 27 | .34 | 4.3 | .70 | 11.6 | .75 | 12.4 | .54 | 9.4 |
| 28 | .40 | 5.4 | .65 | 10.9 | .75 | 12.4 | .50 | 8.9 |
| 29 | .41 | 5.6 | .75 | 12.4 | .75 | 12.4 | .50 | 8.9 |
| 30 | .78 | 13.4 | .75 | 12.4 | .75 | 12.4 | .45 | 8.3 |
| 31 | .80 | 13.8 | .75 | 12.4 | .75 | 12.4 | | |
| Mean | | 6.1 | | 11.3 | | 11.8 | | 9.0 |

NOTE.—These discharges are believed to represent the total flow of the creek from August 3 to 20, 1906, and from about July 23 to September 8, and September 19 to 30, 1907.

SEEPAGE MEASUREMENTS ON MIOCENE DITCH.

Measurements were made at different times at several points along the main ditch and also on the Jett Creek branch to determine the loss by seepage from the different sections of the ditch. The discharge of the branches and principal feeders was found by measuring the flow in the ditch above and below them. The figures obtained for the section between points of measurement were therefore the resultant of the gain from creeks too small to measure and the loss by seepage and leakage. The measurements of July 3 to 4 and July 27 were made at periods of extreme low water, and show a much larger loss than those of September 11 to 12, when there was much more water entering. On the latter date the ditch was gaining along much of its course. These measurements are of value to ditch builders in showing the losses which may be expected in ditches in frozen countries.

*Seepage measurements of Miocene ditch, 1906.*

MAIN DITCH FROM NOME RIVER TO GLACIER CREEK.

| Date. | Point of measurement. | Discharge. | Gain. | Loss. |
|---|---|---|---|---|
| | | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* |
| July 3 | Nome River intake | 21 | | |
| Do | Above Hobson | 15.8 | | 5.2 |
| July 4 | ....do | 20.5 | | |
| Do | Below Hobson | 31.0 | 10.5 | |
| Do | Above flume | 28.1 | | 2.9 |
| Do | Below flume | 29.8 | 1.7 | |
| Do | Above Ex | 27.9 | | 1.9 |
| Do | Above tunnel | 28.8 | .9 | |
| July 27 | Nome River intake | 28 | | |
| Do | Black Point | 25.7 | | 2.3 |
| Do | Above Dorothy | 26.2 | .5 | |
| Do | Below Dorothy | 26.0 | | .2 |
| Do | Above Hobson | 23.7 | | 2.3 |
| Do | Below Hobson | 38.0 | 14.3 | |
| Do | Grouse Creek branch | 1.7 | | |
| | Total above flume | 39.7 | | |
| Do | Below flume | 36.5 | | 3.2 |
| August 2 | ....do | 28.3 | | |
| Do | Glacier branch | 13.0 | | |
| Do | Dexter branch | 13.3 | | |
| | Total | 26.3 | | 2.0 |
| September 11 | Nome River at intake | 29.8 | | |
| Do | Black Point | 30.7 | .9 | |
| Do | Above Dorothy | 30.3 | | .4 |
| Do | Above Hobson | 30 | | .3 |
| Do | Below Hobson | 44.4 | 14.4 | |
| Do | Grouse Creek branch | 2.4 | | |
| | Total above flume | 46.8 | | |
| Do | Below flume | 43.9 | | 2.9 |
| September 12 | ....do | [a] 43 | | |
| Do | Glacier Fork at Ex | 30.3 | | |
| Do | Dexter Fork at Ex | 15.3 | | |
| | Total at Ex | 45.6 | 2.6 | |
| September 13 | Glacier Fork at Ex | [a] 29.6 | | |
| Do | Above tunnel | 29.4 | | .2 |
| July 29 | Intake, David Creek branch | 6.9 | | |
| Do | Outlet, David Creek branch | 6.4 | | .5 |

JETT CREEK BRANCH.

| | | | | |
|---|---|---|---|---|
| September 10 | Copper Creek ditch, intake | 2.5 | | |
| Do | Copper Creek ditch, outlet into Jett Creek ditch | 1.8 | | 0.7 |
| Do | Jett Creek ditch, intake | 4.2 | | |
| | Total | 6.0 | | |
| Do | Jett Creek ditch, below junction with Copper Creek ditch | 5.7 | | .3 |
| Do | Outlet over Nugget divide | 5.3 | | .4 |

[a] Estimated.

MISCELLANEOUS MEASUREMENTS.

The following measurements were made at the points stated during the two years:

*Miscellaneous measurements of Miocene ditch, 1906–7.*

| Date. | Point of measurement. | Discharge. |
|---|---|---|
| 1906. | | *Sec.-ft.* |
| August 23 | Above Dorothy Creek siphon | 39.5 |
| September 25 | ....do | 41.4 |
| 1907. | | |
| July 2 | Grouse Creek branch | 11.7 |
| July 20 | Above Snow Gulch | 31.9 |
| July 31 | Copper Creek branch | 3.5 |
| August 20 | Above Dorothy Creek siphon | 40.9 |
| September 28 | Grouse Creek branch | 5.8 |

CAMPION DITCH AT BLACK POINT.

The Campion ditch diverts water from Buffalo Creek at an elevation of 610 feet. Its lower end terminates in Dorothy Creek, into which it discharges. The ditch has a width of 6 feet on the bottom and 9 feet on top, is 2 feet deep, and has a mean velocity of 2 feet per second when running full. The water was turned in at 1 p. m., July 6, 1906. The ditch broke near its outlet at 7 a. m., July 8. It was repaired and water turned in again on the 19th. All water was turned out from 9.30 p. m. August 12 to 2.30 p. m. August 13.

It ran continuously from July 7 to September 29, 1907, except September 23, when the water was turned out on account of slush ice.

Measurements were taken on the ditch in order to determine the natural flow of Nome River below the junction of Buffalo and Deep Canyon creeks.

*Discharge measurements of Campion ditch at Black Point, 1906–7.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-ft.* | 1907. | *Feet.* | *Sec.-ft.* |
| July 7 | 0.80 | 11.9 | July 10 | 0.88 | 9.9 |
| July 20 | .60 | 8.9 | July 12 | .35 | 2.7 |
| July 21 | .70 | 10.2 | July 17 | .79 | 8.2 |
| August 2 | .67 | 9.7 | August 4 | 1.04 | 13.9 |
| August 11 | 1.36 | 27.5 | | | |
| August 18 | .76 | 12.0 | | | |
| August 23 | 1.10 | 19.6 | | | |
| August 31 | 1.00 | 16.8 | | | |

*Daily gage height and discharge of Campion ditch, 1906–7.*

[Drainage area at point of diversion, 8.2 square miles.]

| Day. | 1906. | | | | | | 1907. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July. | | August. | | September. | | July. | | August. | | September. | |
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | 0.69 | 10.1 | 0.98 | 16.5 | ..... | ..... | 1.00 | 12.8 | 1.10 | 15.7 |
| 2 | ..... | ..... | .68 | 10.0 | .90 | 14.5 | ..... | ..... | 1.00 | 12.8 | 1.12 | 16.3 |
| 3 | ..... | ..... | .65 | 9.5 | 1.02 | 17.5 | ..... | ..... | 1.00 | 12.8 | 1.12 | 16.3 |
| 4 | ..... | ..... | .62 | 9.0 | 1.04 | 18.0 | ..... | ..... | .99 | 12.5 | 1.10 | 15.7 |
| 5 | ..... | ..... | .56 | 8.2 | 1.00 | 17.0 | ..... | ..... | .95 | 11.5 | 1.06 | 14.5 |
| 6 | ..... | ..... | .61 | 8.9 | 1.02 | 17.5 | ..... | ..... | .90 | 10.3 | 1.11 | 16.0 |
| 7 | 0.88 | 14.1 | .69 | 10.1 | .96 | 16.0 | 0.71 | 6.8 | .92 | 10.8 | 1.08 | 15.1 |
| 8 | ..... | ..... | .70 | 10.3 | .96 | 16.0 | .58 | 5.1 | .96 | 11.8 | 1.06 | 14.5 |
| 9 | ..... | ..... | .73 | 10.9 | 1.00 | 17.0 | .80 | 8.3 | .98 | 12.3 | 1.16 | 17.4 |
| 10 | ..... | ..... | .77 | 11.7 | 1.08 | 19.0 | .81 | 8.5 | .90 | 10.3 | .82 | 8.7 |
| 11 | ..... | ..... | 1.13 | 20.4 | 1.07 | 18.8 | .66 | 6.0 | .90 | 10.3 | .65 | 5.9 |
| 12 | ..... | ..... | 1.05 | 18.2 | 1.02 | 17.5 | .52 | 4.4 | .94 | 11.3 | .93 | 11.0 |
| 13 | ..... | ..... | 1.09 | 19.2 | 1.06 | 18.5 | .77 | 7.8 | .94 | 11.3 | 1.00 | 12.8 |
| 14 | ..... | ..... | 1.02 | 17.5 | 1.02 | 17.5 | .69 | 6.5 | .98 | 12.3 | .91 | 10.5 |
| 15 | ..... | ..... | .92 | 15.0 | .98 | 16.5 | .66 | 6.0 | .89 | 10.1 | .97 | 12.0 |
| 16 | ..... | ..... | .80 | 12.3 | .93 | 15.2 | .73 | 7.1 | 1.08 | 15.1 | .92 | 10.8 |
| 17 | ..... | ..... | .80 | 12.3 | .92 | 15.0 | .70 | 6.7 | .99 | 12.5 | .97 | 12.0 |
| 18 | ..... | ..... | .78 | 11.9 | .90 | 14.5 | .95 | 11.5 | 1.09 | 15.4 | 1.01 | 13.1 |
| 19 | ..... | ..... | .75 | 11.3 | 1.10 | 19.5 | .84 | 9.1 | 1.01 | 13.1 | 1.06 | 14.5 |
| 20 | ..... | ..... | .80 | 12.3 | .98 | 16.5 | .90 | 10.3 | .98 | 12.3 | 1.18 | 18.0 |
| 21 | ..... | ..... | .76 | 11.5 | .50 | 7.5 | .94 | 11.3 | 1.03 | 13.6 | .98 | 12.3 |
| 22 | ..... | ..... | 1.01 | 17.2 | .60 | 8.7 | .88 | 9.9 | 1.04 | 13.9 | .99 | 12.5 |
| 23 | ..... | ..... | 1.16 | 21.3 | .75 | 11.3 | .93 | 11.0 | 1.02 | 13.4 | ..... | 0 |
| 24 | ..... | ..... | .99 | 16.8 | .72 | 10.7 | .89 | 10.1 | 1.02 | 13.4 | .98 | 12.2 |
| 25 | .92 | 15.0 | .93 | 15.2 | .91 | 14.8 | .88 | 9.9 | 1.00 | 12.8 | .99 | 12.5 |
| 26 | .78 | 11.9 | 1.15 | 21.0 | .96 | 16.0 | .89 | 10.1 | 1.09 | 15.4 | 1.06 | 14.5 |
| 27 | .75 | 11.3 | 1.16 | 21.3 | 1.02 | 17.5 | .83 | 8.9 | 1.08 | 15.1 | 1.04 | 13.9 |
| 28 | .82 | 12.7 | 1.14 | 20.7 | .98 | 16.5 | .86 | 9.5 | 1.06 | 14.5 | 1.03 | 13.6 |
| 29 | .78 | 11.9 | 1.09 | 19.2 | .95 | 15.8 | .91 | 10.5 | 1.05 | 14.2 | .98 | 12.2 |
| 30 | .76 | 11.5 | 1.00 | 17.0 | .94 | 15.5 | 1.05 | 14.2 | 1.12 | 16.3 | ..... | 0 |
| 31 | .72 | 10.7 | .99 | 16.8 | ..... | ..... | 1.07 | 14.8 | 1.08 | 15.1 | ..... | ..... |
| Mean | ..... | 12.4 | ..... | 14.4 | ..... | 15.8 | ..... | 9.0 | ..... | 12.9 | ..... | 12.5 |

## SEWARD DITCH.

The Seward ditch was built in 1905–6 to take water from Nome River just below Dorothy Creek, at an elevation of 407 feet, and convey it to Saturday Creek for use along the ancient beach line. Its total length is 38 miles. The water is conducted across Hobson and Clara creeks by 42-inch continuous stave-pipe siphons having lengths of 1,050 and 800 feet. A part of the flow of Hobson Creek is diverted by a branch ditch.[a] In 1907 a gage was established near the intake and read by the ditch walker.

Measurements to determine the flow and also the seepage of this ditch were made as follows:

*Seepage measurements of Seward ditch, 1906.*

| Date. | Point of measurement. | Discharge. | Gain. | Loss. |
|---|---|---|---|---|
| | | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* |
| July 29 | Intake | 19.7 | ..... | ..... |
| Do | Above Clara Creek | 20.6 | 0.9 | ..... |
| Do | Hobson branch | 4.0 | ..... | ..... |
| | | 24.6 | | |
| Do | Above Trout Creek | 22.0 | ..... | 2.6 |

[a] For measurements of the Hobson Creek branch, see page 24.

Other measurements were made at the intake as follows:

*Discharge measurements of Seward ditch at intake, 1906–7.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-ft.* | 1907. | *Feet.* | *Sec.-ft.* |
| August 18 | | 25 | July 11 | 0.55 | 19.1 |
| August 30 | | 26 | July 18 | .72 | 23.2 |
| September 13 | | [a] 32 | July 24 | .82 | 25.7 |

[a] Computed from gage reading.

*Daily gage height and discharge of Seward ditch at intake, 1907.*

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 0.85 | 27.2 | 0.90 | 29.0 | 18 | 0.70 | 22.5 | 0.85 | 27.2 | 0.85 | 27.2 |
| 2 | | | .85 | 27.2 | .89 | 28.6 | 19 | .75 | 23.8 | .84 | 26.9 | .82 | 26.2 |
| 3 | | | .85 | 27.2 | .89 | 28.6 | 20 | .75 | 23.8 | .84 | 26.9 | .82 | 26.2 |
| 4 | | | .80 | 25.4 | .89 | 28.6 | 21 | .75 | 23.8 | .90 | 29.0 | .78 | 24.8 |
| 5 | | | .74 | 23.6 | .88 | 28.3 | 22 | .75 | 23.8 | .84 | 26.9 | .78 | 24.8 |
| 6 | | | .72 | 23.0 | .88 | 28.3 | 23 | .75 | 23.8 | .87 | 27.9 | .80 | 25.4 |
| 7 | | | .71 | 22.8 | .89 | 28.6 | 24 | .75 | 23.8 | .87 | 27.9 | .80 | 25.4 |
| 8 | | | .72 | 23.0 | .88 | 28.3 | 25 | .80 | 25.4 | .90 | 29.0 | .80 | 25.4 |
| 9 | | | .74 | 23.6 | .85 | 27.2 | 26 | .82 | 26.2 | .90 | 29.0 | .80 | 25.4 |
| 10 | | | .72 | 23.0 | .81 | 25.8 | 27 | .82 | 26.2 | .85 | 27.2 | .80 | 25.4 |
| 11 | 0.60 | 20.1 | .72 | 23.0 | ..... | 0 | 28 | .88 | 28.3 | .85 | 27.2 | .75 | 23.8 |
| 12 | .62 | 20.5 | .71 | 22.8 | .82 | 26.2 | 29 | .82 | 26.2 | .87 | 27.9 | .74 | 23.6 |
| 13 | .65 | 21.3 | .78 | 24.8 | .85 | 27.2 | 30 | .85 | 27.2 | .89 | 28.6 | .75 | 23.8 |
| 14 | .65 | 21.3 | .77 | 24.5 | .84 | 26.9 | 31 | .85 | 27.2 | .89 | 28.6 | ..... | ..... |
| 15 | .70 | 22.5 | .71 | 22.8 | .84 | 26.9 | | | | | | | |
| 16 | .70 | 22.5 | .88 | 28.3 | .84 | 26.9 | Mean | ..... | 23.9 | ..... | 26.2 | ..... | 25.7 |
| 17 | .70 | 22.5 | .88 | 28.3 | .85 | 27.2 | | | | | | | |

## PIONEER DITCH.

The Pioneer ditch, begun in 1905 and completed in 1907, has its intake on Nome River just below the mouth of Christian Creek, about 3 miles below the Seward intake and at an elevation of about 330 feet. It has a total length of 38 miles and extends to Anvil Creek. There are three siphons, composed of two lines of 30-inch riveted steel pipes—one 545 feet long across Hobson Creek, one 1,050 feet long across Banner Creek, and one 755 feet long across Dexter Creek. Several narrow gulches and gullies eroded by waste water from the other ditches are crossed by flumes.

Daily gage heights and discharges of the Pioneer ditch at the intake and of Nome River are given on page 22.

## GRAND CENTRAL RIVER DRAINAGE BASIN.

### GENERAL DESCRIPTION.

On account of its elevation and well-sustained flow, Grand Central River offers one of the most valuable unused water supplies of Seward Peninsula. The drainage area of this stream, which is about 12 miles long and 2 miles wide, is almost surrounded by ridges of the Sawtooth Range (Kigluaik Mountains), having elevations of 1,500 to 4,000 feet. (See Pl. VI, *A* and *B*.)

The river is formed near the foot of Mount Osborn, at an elevation of about 700 feet, by the junction of North and West forks, and flows in a southerly direction into Salmon Lake. From the forks to Salmon Lake the river has a fall of about 300 feet, and at high stages spreads over a wide gravelly bed. On either side there is a little bottom land, from which the mountains rise abruptly.

The principal tributaries of Grand Central River below the forks are Gold Run and Rainbow Creek from the east, and Thompson, Thumit, Nugget, Jett, and Morning Call creeks from the west. These tributary streams, with the exception of Nugget Creek, drain short, steep-sided gulches. They have considerable fall and are fed from melting snow.

In order to make the water from this drainage basin available for use at Nome it has to be diverted over the Nugget divide, which has an elevation of 785 feet. One such diversion has been made from Jett Creek and Copper Creek, from which water is taken by the Jett Creek ditch into the Miocene ditch.

The Miocene Ditch Company is building a ditch which will tap West Fork above the mouth of the Crater Lake outlet and North Fork at an elevation of about 850 feet. This ditch will extend down the west side of the valley, crossing and tapping Thompson and Thumit creeks, and will pass over the Nugget divide, where it will be taken up by the main Miocene ditch and carried to Glacier and Anvil creeks.

The Wild Goose Mining and Trading Company has started from Crater Lake a 42-inch continuous wood-pipe line, which will extend along the south side of the valley over the Nugget divide and down Nome Valley to Anvil Mountain. The company plans to dam and use Crater Lake as a storage resorvoir, into which the waters from North and West forks will be diverted by lateral pipes. Other laterals will carry the water of Gold Run and Thompson Creek into the main pipe line. Measurements made in this drainage are shown on the following pages.

### NORTH FORK OF GRAND CENTRAL RIVER.

North Fork of Grand Central River rises in a cirque at the base of Mount Osborn, which is surrounded by almost perpendicular moun-

*A*. UPPER GRAND CENTRAL RIVER DRAINAGE.

*B*. MOUNT OSBORN, JULY, 1906.

tains rising from 1,000 to 3,000 feet above the bed of the stream. This cirque contains a small glacier, the melting of which maintains a very steady flow. The flow is increased by a large spring at an elevation of about 860 feet.

Discharge measurements on this stream in 1906 were made at elevations of about 750 feet and 1,030 feet, points which give the flow at the ditch and pipe intakes, respectively. The bed is very rough and it is difficult to obtain satisfactory measuring sections. Gage heights were read at the time of the measurements by measuring down from reference points on rocks.

In 1907 a gaging station was established about 100 yards above the junction of the forks to take the place of the one at the ditch intake. The increase in flow between the stations is small. The gage was read by Cornelius Edmunds.

*Daily gage height and discharge of North Fork of Grand Central River near ditch intake, 1906.*

[Elevation, 750 feet; drainage area, 5.4 square miles.]

| Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | 23 | | 30 | | 44 |
| 2 | | (23) | | 30 | 0.92 | [b] 44 |
| 3 | | (23) | | 30 | | 38 |
| 4 | | (25) | | 32 | | 38 |
| 5 | | | | 32 | | 40 |
| 6 | | | | 29 | | 37 |
| 7 | | | 0.81 | [b] 32 | | 33 |
| 8 | | | | 33 | | 31 |
| 9 | | | | 31 | .76 | [b] 27 |
| 10 | | | | 33 | | 28 |
| 11 | 1.10 | [a] 67 | | 32 | | 27 |
| 12 | | | | 27 | | (26) |
| 13 | | | | 27 | | 26 |
| 14 | | | | 28 | | 27 |
| 15 | | | | 28 | | 26 |
| 16 | | | .76 | [a] 27 | | 25 |
| 17 | | | .74 | [b] 25 | | 25 |
| 18 | | | | 27 | | 27 |
| 19 | | | | 25 | | |
| 20 | | 40 | | 27 | | |
| 21 | | (45) | | (32) | | |
| 22 | .85 | [a] 38 | | (36) | 1.5 | [b c] 120 |
| 23 | | 42 | | (60) | | |
| 24 | | 61 | .85 | [b] 37 | | |
| 25 | .95 | [a] 47 | | 40 | | |
| 26 | .90 | [b] 42 | | (40) | | |
| 27 | | 45 | | (67) | | |
| 28 | | 50 | | 67 | | |
| 29 | | 38 | | 71 | | |
| 30 | | 42 | | 54 | | |
| 31 | | 28 | | 48 | | |
| Mean | | [d] 39.9 | | 36.7 | | [e] 31.6 |
| Run-off per square mile | | 7.39 | | 6.80 | | 5.85 |
| Run-off depth in inches | | 4.67 | | 7.84 | | 3.92 |

[a] Measurements.
[b] Estimates based on gage readings.
[c] Not included in mean.
[d] 17 days.
[e] 18 days.

NOTE.—These values were obtained by subtracting the sum of the discharges at the West Fork and Crater Lake station from the flow below the forks. For the days for which this method does not give consistent results the discharges are based on the West Fork flow and are in parentheses. From July 5 to 19 the flow did not fall below 40 second-feet. The flow on June 26 was 43 second-feet.

*Discharge measurements of North Fork of Grand Central River at the forks, 1907.*

[Elevation 690 feet.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| July 8 | 1.31 | 65 | August 13 | 1.07 | 28 |
| July 16 | 1.19 | 41 | August 26 | 1.36 | 70 |
| July 25 | 1.23 | 47 | September 6 | 1.18 | 36 |
| July 26 | 1.20 | 45 | September 16 | 1.44 | 56 |
| August 5 | 1.11 | 34 | | | |

*Daily gage height and discharge of North Fork of Grand Central River at the forks, 1907.*

[Drainage area, 6.9 square miles.]

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | 1.16 | 37 | 1.32 | 64 | 19 | ..... | 50 | 1.28 | 56 | 1.52 | 39 |
| 2 | ..... | ..... | 1.20 | 42 | 1.22 | 45 | 20 | ..... | 60 | 1.34 | 68 | 1.50 | 36 |
| 3 | ..... | ..... | 1.15 | 36 | 1.14 | 35 | 21 | ..... | 80 | 1.44 | 89 | 1.29 | 35 |
| 4 | ..... | ..... | 1.15 | 36 | 1.22 | 45 | 22 | ..... | 51 | 1.44 | 89 | 1.10 | 21 |
| 5 | ..... | ..... | 1.12 | 33 | 1.25 | 50 | 23 | ..... | 50 | 1.41 | 83 | 1.18 | 25 |
| 6 | ..... | ..... | 1.10 | 31 | 1.16 | 37 | 24 | ..... | 46 | 1.32 | 64 | ..... | ..... |
| 7 | ..... | ..... | 1.10 | 31 | 1.10 | 31 | 25 | 1.22 | 45 | 1.30 | 60 | ..... | ..... |
| 8 | 1.31 | 62 | 1.10 | 31 | 1.07 | 29 | 26 | 1.20 | 42 | 1.37 | 75 | ..... | ..... |
| 9 | ..... | 56 | 1.10 | 31 | 1.50 | 102 | 27 | 1.19 | 41 | 1.38 | 77 | ..... | ..... |
| 10 | 1.25 | 50 | 1.08 | 29 | 2.15 | 238 | 28 | 1.14 | 35 | 1.31 | 62 | ..... | ..... |
| 11 | ..... | 70 | 1.10 | 31 | 2.10 | 194 | 29 | 1.11 | 32 | 1.74 | 152 | ..... | ..... |
| 12 | ..... | 60 | 1.10 | 31 | 1.68 | 106 | 30 | 1.14 | 35 | 1.66 | 136 | ..... | ..... |
| 13 | ..... | 65 | 1.08 | 29 | 1.52 | 72 | 31 | 1.16 | 37 | 1.42 | 85 | ..... | ..... |
| 14 | ..... | 50 | 1.11 | 32 | 1.50 | 68 | Mean | ..... | 48.7 | ..... | 58.1 | ..... | 64.7 |
| 15 | ..... | 41 | 1.05 | 27 | 1.49 | 66 | Run-off per square mile | ..... | 7.06 | ..... | 8.42 | ..... | 9.38 |
| 16 | 1.19 | 41 | 1.34 | 68 | 1.44 | 57 | Run-off, depth in inches | ..... | 6.30 | ..... | 9.71 | ..... | 8.02 |
| 17 | ..... | 38 | 1.40 | 81 | 1.40 | 49 | | | | | | | |
| 18 | ..... | 42 | 1.35 | 70 | 1.37 | 45 | | | | | | | |

NOTE.—Channel conditions were changed during the high water of September 10, and a new rating table was used after that date. Discharges for days between July 8 and 25, when the gage was not read were obtained by the aid of a hydrograph.

*Daily discharge in second-feet of North Fork of Grand Central River at pipe intake, 1906–7.*

[Elevation, 1,030 feet; drainage area, 2.3 square miles.]

| Day. | 1906. | | | 1907. | | |
|---|---|---|---|---|---|---|
| | July. | Aug. | Sept. | July. | Aug. | Sept. |
| 1 | 21 | 22 | 31 | ..... | 30 | 46 |
| 2 | 21 | 22 | [a] 31 | ..... | 34 | 32 |
| 3 | 21 | 22 | 27 | ..... | 29 | 25 |
| 4 | 22 | 24 | 27 | ..... | 29 | 32 |
| 5 | ..... | 24 | 28 | ..... | [a] 27 | 36 |
| 6 | ..... | 21 | 26 | ..... | 25 | 27 |
| 7 | ..... | [a] 23 | 23 | ..... | 25 | 22 |
| 8 | ..... | 25 | 22 | [a] 42 | 25 | 21 |
| 9 | ..... | 23 | [a] 19 | 37 | 25 | 74 |
| 10 | ..... | 25 | 20 | 40 | 23 | 171 |
| 11 | ..... | 24 | 19 | 56 | 23 | 140 |
| 12 | ..... | 20 | 17 | 48 | 23 | 76 |
| 13 | ..... | 20 | 18 | 52 | 22 | 52 |
| 14 | ..... | 21 | 19 | 40 | 24 | 49 |

[a] Measurements. Other discharges are obtained by taking about the same percentage of the flow at the lower station, as was found on the dates of measurements. This varied from 70 to 90 per cent. Gagings on June 20, 1906, gave 30 second-feet, and on June 26, 1906, 43 second-feet. The flow from July 5 to 19, 1906, probably exceeded 35 second-feet.

*Daily discharge in second-feet of North Fork of Grand Central River at pipe intake, 1906–7*—Continued.

| Day. | 1906. | | | 1907. | | |
|---|---|---|---|---|---|---|
| | July. | Aug. | Sept. | July. | Aug. | Sept. |
| 15 | ..... | 21 | 18 | 33 | 20 | 47 |
| 16 | ..... | 20 | 18 | 33 | 51 | a 41 |
| 17 | ..... | a 19 | 17 | 30 | 61 | 35 |
| 18 | ..... | 20 | 19 | 34 | 52 | 32 |
| 19 | ..... | 19 | ..... | 40 | 42 | 28 |
| 20 | 31 | 20 | ..... | 48 | 51 | 26 |
| 21 | 35 | 24 | ..... | 64 | 67 | 25 |
| 22 | 30 | 27 | ..... | 41 | 67 | 15 |
| 23 | 33 | 45 | ..... | 40 | 62 | 18 |
| 24 | 48 | a 28 | ..... | 37 | 48 | ..... |
| 25 | 37 | 30 | ..... | 37 | a 43 | ..... |
| 26 | a 33 | 30 | ..... | a 38 | 54 | ..... |
| 27 | 34 | 50 | ..... | 33 | 55 | ..... |
| 28 | 38 | 50 | ..... | 28 | 44 | ..... |
| 29 | 28 | 53 | ..... | 26 | 110 | ..... |
| 30 | 32 | 40 | ..... | 28 | 98 | ..... |
| 31 | 21 | 36 | ..... | 30 | 61 | ..... |
| Mean | 30.3 | 27.4 | 22.2 | 39.0 | 43.5 | 46.5 |
| Run-off per square mile | 13.2 | 11.9 | 9.65 | 16.9 | 18.9 | 20.2 |
| Run-off, depth in inches | 7.86 | 13.7 | 6.46 | 15.1 | 21.8 | 17.3 |

a Measurements. Other discharges are obtained by taking about the same percentage of the flow at the lower station, as was found on the dates of measurements. This varied from 70 to 90 per cent. Gagings on June 20, 1906, gave 30 second-feet, and on June 26, 1906, 43 second-feet. The flow from July 5 to 19, 1906, probably exceeded 35 second-feet.

A limestone spring at an elevation of 850 feet discharges into North Fork near the proposed ditch intake, and is the largest of a considerable number of springs in the upper Grand Central Valley. The following measurements of the flow of this spring were made in 1907: July 10, 3.8 second-feet; September 5, 7.4 second-feet.

### WEST FORK OF GRAND CENTRAL RIVER.

West Fork of Grand Central River has its source in Mount Osborn, and flows between Mount Osborn and the high ridges which separate the Grand Central drainage from the Sinuk drainage. It is fed from snow storage for a greater part of the season, by limestone springs, and by Crater Lake, which lies at an elevation of 973 feet and has an area of about 106 acres.

There is considerable glacial drift in the lower part of the basin containing several depressions, one having an area of nearly 5 acres. These depressions fill with water during a rain and gradually drain off through the gravel.

Two gaging stations were established on the fork in 1906 at elevations of 1,010 and 860 feet. The lower station is just above the outlet to Crater Lake and shows the flow at the proposed ditch intake. The other station was established to obtain the flow at the proposed pipe intake by comparison with the flow at the lower station. The flow was about 70 per cent of that at the lower station during the earlier part of the season of 1906. As the snow above the pipe intake melted away and the flow of the springs between the intakes in-

creased, this percentage became about 35 for low water and 50 for higher stages. The cold weather in September checked the flow at high levels and reduced the percentage to 32. During 1907 the percentages were almost the same as for the corresponding dates of 1906. In 1907 an additional station was established just above the forks, where the flow from Crater Lake is included.

*Discharge measurements of West Fork of Grand Central River at the forks, 1907.*

[Elevation, 690 feet.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| July 10 | 1.88 | 107 | August 13 | 1.61 | 46 |
| July 16 | 1.77 | 80 | August 26 | 1.71 | 61 |
| July 26 | 1.74 | 77 | September 5 | 1.62 | 44 |
| August 5 | 1.65 | 50 | September 17 | 1.70 | 61 |

NOTE.—These measurements were made by subtracting the flow of North Fork from that of the river below the forks, taking both from the rating curves of the two stations, all three gages being read at the same time.

*Daily gage height and discharge of West Fork of Grand Central River at the forks, 1907.*

[Drainage area, 7.7 square miles.]

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.72 | 66 | 1.82 | 93 | 20 | | 100 | 1.78 | 82 | 1.61 | 44 |
| 2 | | | 1.71 | 64 | 1.78 | 82 | 21 | | 140 | 1.82 | 93 | 1.59 | 41 |
| 3 | | | 1.70 | 61 | 1.63 | 47 | 22 | | 90 | 1.78 | 82 | 1.54 | 34 |
| 4 | | | 1.70 | 61 | 1.72 | 66 | 23 | | 80 | 1.72 | 66 | 1.61 | 44 |
| 5 | | | 1.65 | 50 | 1.68 | 57 | 24 | | 76 | 1.65 | 50 | | |
| 6 | | | 1.60 | 42 | 1.68 | 57 | 25 | 1.75 | 74 | 1.64 | 48 | | |
| 7 | | | 1.60 | 42 | 1.76 | 77 | 26 | 1.75 | 74 | 1.63 | 47 | | |
| 8 | 1.93 | 129 | 1.62 | 45 | 1.84 | 99 | 27 | 1.70 | 61 | 1.64 | 48 | | |
| 9 | | 95 | 1.64 | 48 | 2.07 | 179 | 28 | 1.65 | 50 | 1.65 | 50 | | |
| 10 | 1.88 | 112 | 1.62 | 45 | 2.70 | 406 | 29 | 1.60 | 42 | 2.32 | 276 | | |
| 11 | | 125 | 1.62 | 45 | 2.37 | 287 | 30 | 1.68 | 57 | 2.38 | 291 | | |
| 12 | | 90 | 1.65 | 50 | 2.12 | 197 | 31 | 1.70 | 61 | 1.88 | 115 | | |
| 13 | | 95 | 1.62 | 45 | 1.82 | 93 | | | | | | | |
| 14 | | 88 | 1.65 | 50 | 1.80 | 87 | Mean | | 84.5 | | 81.0 | | 100 |
| 15 | | 80 | 1.62 | 45 | 1.80 | 87 | Run-off, per square mile | | 11.0 | | 10.5 | | 13.0 |
| 16 | 1.77 | 79 | 1.88 | 112 | 1.74 | 71 | Run-off, depth in inches | | 9.82 | | 12.1 | | 11.1 |
| 17 | | 70 | 2.00 | 154 | 1.70 | 61 | | | | | | | |
| 18 | | 75 | 1.92 | 125 | 1.67 | 54 | | | | | | | |
| 19 | | 85 | 1.88 | 112 | 1.62 | 45 | | | | | | | |

*Discharge measurements of West Fork of Grand Central River at ditch intake, 1906–7.*

[Elevation, 860 feet.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-ft.* | 1907. | *Feet.* | *Sec.-ft.* |
| June 19 | | 40.4 | July 8 | 1.30 | 69 |
| June 26 | | 38 | July 16 | 1.18 | 51 |
| July 1 | | 28.6 | July 26 | 1.13 | 44 |
| July 10 | 1.65 | 115 | August 6 | 1.01 | 32 |
| July 11 | 1.53 | 86 | August 25 | 1.18 | 35 |
| July 22 | 1.20 | 38.1 | September 5 | 1.18 | 39 |
| July 24 | 1.41 | 58 | September 16 | 1.37 | 48 |
| July 25 | 1.34 | 50 | | | |
| August 6 | 1.12 | 30.9 | | | |
| August 16 | 1.01 | 23 | | | |

*Daily gage height and discharge of West Fork of Grand Central River at ditch intake, 1906–7.*

[Elevation, 860 feet; drainage area, 5.4 square miles.]

| Day. | 1906. | | | | | | 1907. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July. | | August. | | September. | | July. | | August. | | September. | |
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | 29 | 1.12 | 30 | 1.27 | 44 | ..... | ..... | ..... | 45 | 1.20 | 41 |
| 2 | 1.10 | 28 | ..... | 30 | 1.24 | 40 | ..... | ..... | ..... | 44 | 1.25 | 47 |
| 3 | 1.00 | 22 | ..... | 30 | 1.20 | 36 | ..... | ..... | ..... | 43 | 1.10 | 31 |
| 4 | 1.10 | 28 | ..... | 34 | 1.12 | 30 | ..... | ..... | ..... | 43 | 1.15 | 36 |
| 5 | 1.80 | 162 | ..... | 34 | 1.08 | 27 | ..... | ..... | 1.08 | 39 | 1.15 | 36 |
| 6 | ..... | ..... | 1.12 | 30 | 1.05 | 25 | ..... | ..... | 1.06 | 37 | 1.15 | 36 |
| 7 | ..... | ..... | 1.15 | 32 | 1.05 | 25 | ..... | ..... | 1.08 | 39 | 1.12 | 33 |
| 8 | ..... | ..... | 1.11 | 29 | 1.02 | 23 | 1.30 | 69 | 1.15 | 47 | 1.10 | 31 |
| 9 | ..... | ..... | ..... | 26 | 1.01 | 23 | ..... | 65 | 1.15 | 47 | 1.35 | 61 |
| 10 | 1.65 | 116 | 1.02 | 23 | 1.00 | 22 | 1.51 | 107 | 1.09 | 40 | 1.85 | 149 |
| 11 | 1.53 | 86 | 1.05 | 25 | 1.00 | 22 | ..... | 110 | 1.10 | 41 | 1.75 | 109 |
| 12 | 1.75 | 144 | 1.10 | 28 | 1.00 | 22 | ..... | 65 | 1.10 | 41 | 1.60 | 84 |
| 13 | 1.60 | 103 | 1.08 | 27 | .98 | 21 | ..... | 68 | 1.12 | 43 | 1.45 | 59 |
| 14 | 1.55 | 90 | 1.05 | 25 | .95 | 20 | ..... | 60 | 1.12 | 43 | 1.40 | 52 |
| 15 | 1.45 | 70 | ..... | 24 | .92 | 19 | ..... | 54 | 1.07 | 38 | 1.40 | 52 |
| 16 | 1.40 | 61 | 1.01 | 23 | .92 | 19 | 1.18 | 51 | 1.49 | 103 | 1.37 | 48 |
| 17 | 1.45 | 70 | 1.00 | 22 | .92 | 19 | ..... | 45 | 1.48 | 77 | 1.32 | 42 |
| 18 | 1.40 | 61 | 1.00 | 22 | 1.00 | 22 | ..... | 50 | 1.38 | 60 | 1.30 | 40 |
| 19 | 1.30 | 47 | 1.00 | 22 | ..... | ..... | ..... | 60 | 1.25 | 43 | 1.28 | 38 |
| 20 | 1.30 | 47 | .98 | 21 | ..... | ..... | ..... | 70 | 1.35 | 56 | 1.28 | 38 |
| 21 | 1.35 | 54 | 1.12 | 30 | ..... | ..... | ..... | 100 | 1.40 | 63 | 1.27 | 37 |
| 22 | 1.20 | 36 | 1.20 | 36 | 1.60 | a103 | ..... | 65 | 1.35 | 56 | 1.22 | 32 |
| 23 | 1.52 | 83 | 1.39 | 60 | ..... | ..... | ..... | 58 | 1.25 | 43 | ..... | 35 |
| 24 | 1.41 | 63 | 1.21 | 37 | ..... | ..... | ..... | 54 | 1.20 | 37 | ..... | ..... |
| 25 | 1.33 | 51 | 1.16 | 33 | ..... | ..... | 1.20 | 54 | 1.18 | 35 | ..... | ..... |
| 26 | 1.25 | 42 | 1.22 | 38 | ..... | ..... | 1.13 | 45 | 1.19 | 36 | ..... | ..... |
| 27 | 1.25 | 42 | 1.35 | 54 | ..... | ..... | ..... | 42 | 1.20 | 37 | ..... | ..... |
| 28 | ..... | 39 | 1.30 | 47 | ..... | ..... | ..... | 34 | 1.18 | 35 | ..... | ..... |
| 29 | 1.20 | 36 | 1.30 | 47 | ..... | ..... | ..... | 28 | 1.50 | 98 | ..... | ..... |
| 30 | 1.15 | 32 | 1.27 | 44 | ..... | ..... | 1.10 | 41 | 1.48 | 82 | ..... | ..... |
| 31 | 1.14 | 31 | ..... | 44 | ..... | ..... | ..... | 45 | 1.38 | 66 | ..... | ..... |
| Mean | ..... | 62.0 | ..... | 32.5 | ..... | 25.5 | ..... | 60.0 | ..... | 50.2 | ..... | 50.7 |
| Run-off per square mile | ..... | 11.5 | ..... | 6.02 | ..... | 4.72 | ..... | 11.1 | ..... | 9.30 | ..... | 9.39 |
| Run-off depth in inches | ..... | 11.5 | ..... | 6.94 | ..... | 5.16 | ..... | 9.90 | ..... | 10.7 | ..... | 8.03 |

a Not included in mean.

NOTE.—Discharges for 1907 have been computed from four rating tables on account of the shifting channel conditions, and are somewhat uncertain. Discharges for days between July 8 and August 5, when the gage was not read, were obtained by the aid of a hydrograph.

*Daily gage height and discharge of West Fork of Grand Central River at pipe intake, 1906–7.*

[Elevation, 1,010 feet; drainage area, 2.8 square miles.]

| Day. | 1906 (discharge). | | | 1907. | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | July. | | August. | | September. | |
| | July. | August. | September. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* | *Feet.* | *Sec.-ft* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | a 19 | 12 | 22 | ..... | ..... | ..... | 14 | ..... | 13 |
| 2 | 18 | 12 | 19 | ..... | ..... | ..... | 14 | ..... | 15 |
| 3 | 15 | 12 | 16 | ..... | ..... | ..... | 14 | ..... | 15 |
| 4 | 18 | 14 | 12 | ..... | ..... | ..... | 14 | ..... | 11 |
| 5 | ..... | 14 | 9 | ..... | ..... | ..... | 12 | .88 | b 11.5 |
| 6 | ..... | a 12 | 9 | ..... | ..... | 0.86 | a 11.3 | ..... | 11 |
| 7 | ..... | 12 | 8 | ..... | ..... | ..... | 12 | ..... | 12 |
| 8 | ..... | 10 | 8 | ..... | 31 | ..... | 15 | ..... | 13 |
| 9 | ..... | 9 | a 7.3 | ..... | 29 | ..... | 15 | ..... | 20 |
| 10 | ..... | 8 | 7 | 1.27 | a 47 | ..... | 13 | ..... | 74 |
| 11 | a 45 | 9 | 7 | ..... | 48 | ..... | 13 | ..... | 54 |
| 12 | 72 | 11 | 7 | ..... | 29 | ..... | 13 | ..... | 40 |
| 13 | 52 | 10 | 7 | ..... | 30 | .91 | b 13.7 | ..... | 28 |
| 14 | 45 | 9 | 6 | ..... | 26 | ..... | 14 | ..... | 25 |
| 15 | 32 | 8 | 6 | ..... | 24 | ..... | 12 | ..... | 25 |
| 16 | 27 | 8 | 6 | ..... | 22 | ..... | 52 | 1.02 | b 23 |
| 17 | 32 | a 7.6 | 6 | ..... | 20 | ..... | 35 | ..... | 17 |
| 18 | 27 | 8 | 7 | ..... | 22 | ..... | 19 | ..... | 13 |
| 19 | 20 | 8 | ..... | ..... | 26 | ..... | 14 | ..... | 12 |
| 20 | 20 | 7 | ..... | ..... | 31 | ..... | 18 | ..... | 12 |
| 21 | 23 | 12 | ..... | ..... | 44 | ..... | 20 | ..... | 12 |
| 22 | a 15 | 16 | ..... | ..... | 29 | ..... | 18 | ..... | 10 |
| 23 | 44 | 30 | ..... | ..... | 26 | ..... | 14 | ..... | 11 |
| 24 | 32 | a 18.5 | ..... | ..... | 24 | ..... | 12 | ..... | ..... |
| 25 | a 25 | 15 | ..... | ..... | 24 | .90 | a 12 | ..... | ..... |
| 26 | 19 | 19 | ..... | a .98 | a 19.3 | ..... | 12 | ..... | ..... |
| 27 | 19 | 27 | ..... | ..... | 18 | ..... | 12 | ..... | ..... |
| 28 | 16 | 24 | ..... | ..... | 15 | ..... | 11 | ..... | ..... |
| 29 | 14 | 24 | ..... | ..... | 12 | ..... | 39 | ..... | ..... |
| 30 | 13 | 22 | ..... | ..... | 18 | ..... | 33 | ..... | ..... |
| 31 | 12 | 22 | ..... | ..... | 20 | ..... | 26 | ..... | ..... |
| Mean | 27.0 | 13.9 | 9.4 | ..... | 26.4 | ..... | 17.6 | ..... | 20.5 |
| Run-off per square mile | 9.64 | 4.96 | 3.36 | ..... | 9.43 | ..... | 6.29 | ..... | 7.32 |
| Run-off, depth in inches | 8.96 | 5.72 | 2.25 | ..... | 8.42 | ..... | 7.25 | ..... | 6.26 |

a Measurements.
b Estimates based on gage readings. Other discharges are obtained by taking about the same percentage of the flow at elevation 860 feet as was found on the dates of measurements. Gagings on June 19, 1906, gave 28 second-feet, and on June 26, 26 second-feet.

## CRATER LAKE OUTLET.

Crater Lake discharges into West Fork of Grand Central River just below the ditch intake on that stream. The lake, which lies in a depression of glacial origin, has an elevation of 973 feet and an area of 106 acres. Its basin adjoins those of Sinuk River and Thompson Creek.

A gaging station was located on the outlet about midway between the lake and West Fork. The stream bed is composed of large angular rocks and has a fall of nearly 300 feet to the mile. It is hard to make measurements on account of the swiftness of the current, and the highest one of 1906 is only approximate. Gage heights were taken by employees of the Wild Goose Mining and Trading Company.

*Discharge measurements of Crater Lake outlet, 1906–7.*

[Elevation, 925 feet.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-ft.* | 1907. | *Feet.* | *Sec.-ft.* |
| June 19 | ..... | 14.2 | July 8 | 1.32 | 36.5 |
| June 26 | ..... | 23.7 | July 16 | 1.18 | 21.1 |
| July 1 | ..... | 13.6 | July 26 | 1.13 | 16.7 |
| July 10 | 1.55 | 59.0 | July 30 | 1.04 | 13.7 |
| July 22 | .96 | 12.0 | August 6 | 1.00 | 10.0 |
| July 24 | 1.10 | 21.5 | August 13 | .99 | 10.6 |
| August 6 | .90 | 7.1 | August 25 | .95 | 8.0 |
| August 8 | .98 | 13.0 | September 5 | .93 | 7.5 |
| August 16 | .80 | 5.6 | | | |
| September 9 | .73 | 4.3 | | | |

*Daily gage height and discharge of Crater Lake outlet, 1906–7.*

[Drainage area, 1.8 square miles.]

| Day. | 1906. | | | | | | 1907. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July. | | August. | | September. | | July. | | August. | | September. | |
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | 14 | 0.85 | 7 | 0.98 | 13 | ..... | ..... | ..... | 20 | 1.03 | 11.8 |
| 2 | 1.00 | 14 | ..... | 7 | .94 | 10 | ..... | ..... | ..... | 20 | 1.10 | 16.0 |
| 3 | 1.00 | 14 | ..... | 8 | .90 | 9 | ..... | ..... | ..... | 17 | 1.08 | 14.7 |
| 4 | 1.15 | 25 | ..... | 8 | .82 | 6 | ..... | ..... | ..... | 17 | 1.15 | 19.7 |
| 5 | 1.65 | 69 | ..... | 9 | .78 | 5 | ..... | ..... | 1.04 | 12.3 | .93 | 7.4 |
| 6 | ..... | ..... | .90 | 9 | .78 | 5 | ..... | ..... | 1.03 | 11.8 | .90 | 6.4 |
| 7 | ..... | ..... | .95 | 11 | .78 | 5 | ..... | ..... | 95 | 8.0 | .85 | 5.2 |
| 8 | ..... | ..... | .96 | 12 | .75 | 4.5 | 1.32 | 36 | 1.03 | 11.8 | .83 | 4.8 |
| 9 | ..... | ..... | ..... | 10 | .73 | 4.3 | ..... | 28 | 1.02 | 11.2 | .80 | 4.2 |
| 10 | 1.55 | 59 | .90 | 9 | .71 | 4.1 | 1.27 | 31 | 1.02 | 11.2 | 1.05 | 12.8 |
| 11 | 1.25 | 33 | .90 | 9 | .69 | 3.9 | ..... | 36 | 1.03 | 11.8 | 1.90 | 106 |
| 12 | 1.45 | 50 | 1.00 | 14 | .68 | 3.8 | ..... | 26 | 1.02 | 11.2 | 1.75 | 88 |
| 13 | 1.30 | 37 | .95 | 11 | .65 | 3.5 | ..... | 30 | 1.04 | 12.3 | 1.40 | 46 |
| 14 | 1.15 | 25 | .90 | 9 | .65 | 3.5 | ..... | 26 | 1.04 | 12.3 | 1.40 | 46 |
| 15 | 1.10 | 21 | ..... | 7 | .61 | 3.1 | ..... | 22 | 1.01 | 10.7 | 1.35 | 40 |
| 16 | 1.15 | 25 | .80 | 5.5 | .61 | 3.1 | 1.18 | 22 | 1.41 | 47 | 1.00 | 10.2 |
| 17 | 1.10 | 21 | .80 | 5.5 | .61 | 3.1 | ..... | 20 | 1.40 | 46 | .97 | 8.9 |
| 18 | 1.05 | 17 | .79 | 5.5 | .75 | 4.5 | ..... | 22 | 1.30 | 34 | .95 | 8.0 |
| 19 | 1.00 | 14 | .80 | 5.5 | ..... | ..... | ..... | 26 | 1.20 | 24 | .94 | 7.7 |
| 20 | 1.00 | 14 | .78 | 5 | ..... | ..... | ..... | 30 | 1.35 | 40 | .92 | 7.0 |
| 21 | 1.05 | 17 | 1.01 | 15 | ..... | ..... | ..... | 40 | 1.40 | 46 | .82 | 4.6 |
| 22 | .96 | 12 | 1.01 | 15 | 1.40 | [a] 46 | ..... | 30 | 1.35 | 40 | .75 | 3.5 |
| 23 | 1.06 | 18 | 1.22 | 31 | ..... | ..... | ..... | 24 | 1.30 | 34 | .75 | 3.5 |
| 24 | 1.10 | 21 | 1.02 | 15 | ..... | ..... | ..... | 22 | 1.35 | 40 | ..... | ..... |
| 25 | 1.05 | 17 | 1.00 | 14 | ..... | ..... | 1.17 | 21 | .95 | 80 | ..... | ..... |
| 26 | 1.02 | 15 | 1.10 | 21 | ..... | ..... | 1.13 | 18.2 | 1.36 | 41 | ..... | ..... |
| 27 | 1.00 | 14 | 1.12 | 23 | ..... | ..... | ..... | 18 | 1.37 | 42 | ..... | ..... |
| 28 | ..... | 12 | 1.10 | 21 | ..... | ..... | ..... | 15 | 1.35 | 40 | ..... | ..... |
| 29 | .90 | 9 | 1.05 | 17 | ..... | ..... | ..... | 12 | 1.45 | 52 | ..... | ..... |
| 30 | .88 | 8 | 1.00 | 14 | ..... | ..... | 1.04 | 12.3 | 1.35 | 40 | ..... | ..... |
| 31 | .88 | 8 | ..... | 13 | ..... | ..... | ..... | 17 | 1.30 | 34 | ..... | ..... |
| Mean | ..... | 22.3 | ..... | 11.8 | ..... | 5.2 | ..... | 24.4 | ..... | 26.0 | ..... | 21.0 |
| Run-off per square mile | ..... | 12.4 | ..... | 6.56 | ..... | 2.89 | ..... | 13.6 | ..... | 14.4 | ..... | 11.7 |
| Run-off, depth in inches | ..... | 12.4 | ..... | 7.56 | ..... | 1.93 | ..... | 12.1 | ..... | 16.6 | ..... | 10.0 |

[a] Not included in mean.

## GRAND CENTRAL RIVER BELOW THE FORKS.

This station was established to obtain the total flow that can be diverted over the Nugget divide from the headwaters of Grand Central River. But little water enters the stream between this station and the proposed ditch intakes. Gage readings were taken during 1906 by employees of the Wild Goose Mining and Trading Company. Gage readings were discontinued in 1907, but measurements were made and the discharge of West Fork obtained by subtracting that of North Fork from the total below the junction. The two stations above the forks replaced the one below the forks in 1907.

*Discharge measurements of Grand Central River below the forks, 1906–7.*

[Elevation, 680 feet.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-feet.* | 1907. | *Feet.* | *Sec.-feet.* |
| July 1 | 0.95 | 63 | July 10 | 1.33 | 145 |
| July 11 | 1.40 | 180 | July 16 | 1.20 | 121 |
| July 24 | 1.29 | 140 | July 26 | 1.19 | 119 |
| Do | 1.22 | 129 | August 5 | 1.02 | 85 |
| July 26 | 1.10 | 101 | August 13 | .97 | 72 |
| August 7 | .89 | 66 | September 5 | 1.06 | 89 |
| August 17 | .79 | 54.4 | | | |

*Daily gage height and discharge of Grand Central River below the forks, 1906.*

[Drainage area, 14.6 square miles.]

| Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-feet.* | *Feet.* | *Sec.-feet.* | *Feet.* | *Sec.-feet.* |
| 1 | 0.95 | 63 | 0.90 | 67 | 1.10 | 100 |
| 2 | .90 | 56 | .90 | 67 | 1.05 | 91 |
| 3 | .95 | 63 | .90 | 67 | 1.00 | 82 |
| 4 | 1.05 | 80 | .95 | 74 | .95 | 74 |
| 5 | 1.87 | 370 | ..... | 74 | .93 | 72 |
| 6 | ..... | ..... | .90 | 67 | ..... | 67 |
| 7 | ..... | ..... | .98 | 79 | ..... | 63 |
| 8 | ..... | ..... | .94 | 73 | ..... | 59 |
| 9 | 1.75 | 325 | .90 | 67 | .80 | 55 |
| 10 | 1.70 | 300 | ..... | 65 | ..... | 54 |
| 11 | 1.45 | 198 | ..... | 66 | .78 | 53 |
| 12 | ..... | 280 | ..... | 68 | .75 | 50 |
| 13 | 1.45 | 198 | ..... | 65 | .75 | 50 |
| 14 | 1.42 | 187 | ..... | 62 | .75 | 50 |
| 15 | ..... | 168 | ..... | 59 | .72 | 48 |
| 16 | ..... | 160 | .81 | 56 | .71 | 47 |
| 17 | 1.40 | 180 | .79 | 54 | ..... | 47 |
| 18 | 1.10 | 100 | ..... | 54 | ..... | 54 |
| 19 | 1.05 | 91 | ..... | 53 | ..... | ..... |
| 20 | 1.10 | 100 | .78 | 53 | ..... | ..... |
| 21 | 1.10 | 100 | ..... | 65 | ..... | ..... |
| 22 | 1.00 | 82 | ..... | 59 | 1.72 | [a]310 |
| 23 | 1.28 | 143 | ..... | 210 | ..... | ..... |
| 24 | 1.29 | 145 | 1.08 | 96 | ..... | ..... |
| 25 | 1.18 | 118 | 1.02 | 86 | ..... | ..... |
| 26 | 1.10 | 100 | ..... | 140 | ..... | ..... |
| 27 | ..... | 100 | ..... | 210 | ..... | ..... |
| 28 | 1.10 | 100 | 1.25 | 135 | ..... | ..... |
| 29 | 1.00 | 82 | 1.25 | 135 | ..... | ..... |
| 30 | 1.00 | 82 | 1.15 | 111 | ..... | ..... |
| 31 | .90 | 67 | 1.12 | 104 | ..... | ..... |
| Mean | ..... | [b]144 | ..... | 85.2 | ..... | [c]62.0 |
| Run-off per square mile | ..... | 9.86 | ..... | 5.84 | ..... | 4.25 |
| Run-off, depth in inches | ..... | 10.27 | ..... | 6.73 | ..... | 2.84 |

[a] Not included in mean. [b] 28 days. [c] 18 days.

NOTE.—The interpolated discharges of Aug. 21–23 and 26–27 are 40 to 45 per cent of the flow at the station below Nugget Creek. This is about the proportion that holds for higher water. Other interpolations are made by comparison with the West Fork and Crater Lake outlet stations.

## GRAND CENTRAL RIVER BELOW NUGGET CREEK.

This station was established June 30, 1906, but it was not possible to obtain regular gage readings until August 12, after which the gage was read once each day by A. W. Peterson. At low water the river at this point is about 50 feet wide and 1 to 2 feet deep, and has a mean velocity of about 2 feet per second. It is impossible to obtain measurements above gage height 1.2 feet by wading. The estimates at this station give practically the total flow of Grand Central River into Salmon Lake.

*Discharge measurements of Grand Central River below Nugget Creek, 1906.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-feet.* | | *Feet.* | *Sec.-feet.* |
| June 24 | | 313 | August 28 | 1.10 | 324 |
| June 30 | 0.57 | 148 | September 9 | .46 | 121 |
| July 7 | .98 | 286 | September 14 | .36 | 101 |
| August 4 | .46 | 123 | | | |

*Mean daily gage height and discharge of Grand Central River below Nugget Creek, 1906.*

[Drainage area, 39 square miles.]

| Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-feet.* | *Feet.* | *Sec.-feet.* | *Feet.* | *Sec.-feet.* |
| 1 | 0.5 | 132 | | | 0.8 | 220 |
| 2 | .45 | 120 | | | .75 | 204 |
| 3 | | | | | .65 | 172 |
| 4 | | | | | .6 | 157 |
| 5 | | | | | .6 | 157 |
| 6 | | | | | .55 | 144 |
| 7 | | | | | .5 | 132 |
| 8 | | | | | .5 | 132 |
| 9 | | | | | .45 | 120 |
| 10 | 1.9 | 750 | | | .42 | 114 |
| 11 | | | | | .4 | 109 |
| 12 | 1.55 | 545 | 0.5 | 132 | .4 | 109 |
| 13 | | | .5 | 132 | .38 | 105 |
| 14 | | | .5 | 132 | .35 | 100 |
| 15 | | | .4 | 109 | .35 | 100 |
| 16 | | | .42 | 114 | .3 | 90 |
| 17 | | | .45 | 120 | .3 | 90 |
| 18 | | | .4 | 109 | .4 | 109 |
| 19 | | | .35 | 100 | 1.2 | 375 |
| 20 | | | .5 | 132 | 2.6 | 1,230 |
| 21 | .6 | 157 | .55 | 144 | 2.2 | 950 |
| 22 | | | .5 | 132 | 1.6 | 570 |
| 23 | | | 1.5 | 520 | 1.6 | 570 |
| 24 | | | .8 | 220 | 1.35 | 445 |
| 25 | | | .7 | 187 | 1.15 | 352 |
| 26 | .5 | 132 | 1.05 | 310 | | |
| 27 | | | 1.5 | 520 | | |
| 28 | | | 1.1 | 330 | | |
| 29 | | | .95 | 272 | | |
| 30 | | | .9 | 255 | | |
| 31 | | | .8 | 220 | | |
| Mean | | | | [a] 210 | | [b] 274 |
| Run-off per square mile | | | | 5.38 | | 7.03 |
| Run-off, depth in inches | | | | 4.00 | | 6.54 |

[a] 20 days.

[b] 25 days.

## GOLD RUN.

Gold Run enters Grand Central River from the east, about 2 miles below the forks. It drains a high cirque which lies between North Fork and Fox Creek, has a rapid fall, and terminates in a large gravel fan. A glacial lake near the head of its valley affords possibilities of storage to regulate the flow. On account of the large flow and the concentration of a considerable fall in a short distance, Gold Run has greater advantages for a high-head power development than any other stream on the south side of the Kigluaik Mountains.

In order to determine the quantity of water from this stream available for diversion across the Nugget divide, a station was established at an elevation of about 800 feet.

*Daily gage height and discharge of Gold Run, 1906–7.*

[Elevation, 800 feet.]

| Day. | 1906. | | | | | | 1907. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July. | | August. | | September. | | July. | | August. | | September. | |
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | 14 | ..... | 18 | ..... | 30 | ..... | ..... | ..... | 24 | ..... | 22 |
| 2 | ..... | a 13 | ..... | 18 | 0.95 | b 26 | ..... | ..... | ..... | 24 | ..... | 25 |
| 3 | ..... | 13 | ..... | 18 | ..... | 23 | ..... | ..... | ..... | 22 | ..... | 25 |
| 4 | ..... | 20 | ..... | 20 | ..... | 20 | ..... | ..... | ..... | 22 | ..... | 30 |
| 5 | ..... | ..... | ..... | 24 | ..... | 17 | ..... | ..... | 1.24 | b 22 | 1.22 | b 20 |
| 6 | ..... | ..... | ..... | 30 | ..... | 16 | ..... | ..... | ..... | 19 | ..... | 16 |
| 7 | ..... | ..... | 1.03 | b 34 | ..... | 15 | ..... | ..... | ..... | 16 | ..... | 14 |
| 8 | ..... | ..... | .90 | b 22 | ..... | 14 | 1.57 | a 72 | ..... | 18 | ..... | 13 |
| 9 | ..... | ..... | .89 | b 21 | ..... | 13 | ..... | 60 | ..... | 18 | ..... | 13 |
| 10 | ..... | ..... | ..... | 20 | .71 | a 12 | ..... | 80 | ..... | 15 | ..... | 25 |
| 11 | ..... | 52 | ..... | 20 | ..... | 12 | ..... | 86 | ..... | 15 | ..... | 120 |
| 12 | 1.21 | a 69 | ..... | 24 | ..... | 12 | ..... | 65 | ..... | 15 | ..... | 90 |
| 13 | ..... | 55 | ..... | 22 | ..... | 11 | ..... | 70 | ..... | 15 | ..... | 70 |
| 14 | ..... | 45 | ..... | 20 | ..... | 11 | ..... | 60 | 1.16 | a 16 | ..... | 60 |
| 15 | ..... | 40 | ..... | 18 | ..... | 11 | ..... | 48 | ..... | 13 | ..... | 50 |
| 16 | ..... | 38 | .81 | b 17 | ..... | 10 | 1.40 | b 42 | ..... | 50 | 1.38 | a 26 |
| 17 | ..... | 42 | .80 | b 16.5 | ..... | 10 | ..... | 38 | ..... | 55 | ..... | 24 |
| 18 | ..... | 24 | ..... | 16 | ..... | 12 | ..... | 42 | ..... | 48 | ..... | 22 |
| 19 | ..... | 20 | ..... | 16 | ..... | ..... | ..... | 48 | ..... | 40 | ..... | 20 |
| 20 | ..... | 22 | ..... | 15 | ..... | ..... | ..... | 54 | ..... | 60 | ..... | 18 |
| 21 | ..... | 23 | ..... | 28 | ..... | ..... | ..... | 70 | ..... | 75 | ..... | 14 |
| 22 | .84 | a 18.5 | ..... | 34 | ..... | ..... | ..... | 45 | ..... | 75 | ..... | 11 |
| 23 | 1.00 | b 30 | ..... | 50 | ..... | ..... | ..... | 40 | ..... | 70 | ..... | 10 |
| 24 | ..... | 30 | ..... | 34 | ..... | ..... | ..... | 35 | ..... | 60 | ..... | ..... |
| 25 | 1.00 | a 30 | .99 | b 29 | ..... | ..... | ..... | 32 | ..... | 56 | ..... | ..... |
| 26 | .93 | b 24 | ..... | 44 | ..... | ..... | ..... | 32 | 1.58 | b 74 | ..... | ..... |
| 27 | ..... | 24 | ..... | 68 | ..... | ..... | ..... | 24 | ..... | 76 | ..... | ..... |
| 28 | ..... | 21 | 1.13 | a 51 | ..... | ..... | ..... | 20 | ..... | 60 | ..... | ..... |
| 29 | ..... | 20 | ..... | 40 | ..... | ..... | 1.20 | b 18 | ..... | 90 | ..... | ..... |
| 30 | ..... | 19 | ..... | 36 | ..... | ..... | 1.25 | a 23 | ..... | 70 | ..... | ..... |
| 31 | ..... | 18 | ..... | 32 | ..... | ..... | ..... | 24 | ..... | 40 | ..... | ..... |
| Mean | ..... | 29.0 | ..... | 27.6 | ..... | 15.3 | ..... | 47.0 | ..... | 41.1 | ..... | 32.1 |

a Measurements.

b Estimates based on gage heights. Other discharges were obtained by plotting a hydrograph passing through the known points and following the rise and fall of the other streams in the vicinity. Gagings made on June 20, 1906, gave 22 second-feet and on June 25, 24 second-feet.

### THOMPSON CREEK.

Thompson Creek enters Grand Central River from the west about 2 miles below the forks. It drains a small glacial cirque almost wholly surrounded by very steep walls ranging from 1,000 to 2,000 feet in height. Measurements were made at a point with an elevation of 720 feet, which gives the amount of water available for diversion over the Nugget divide.

*Daily gage height and discharge of Thompson Creek, 1906–7.*

[Elevation, 720 feet; drainage area, 2.5 square miles.]

| Day. | 1906. | | | | | | 1907. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July. | | August. | | September. | | July. | | August. | | September. | |
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | 11 | ..... | 9 | ..... | 19 | ..... | ..... | ..... | 30 | ..... | 16 |
| 2 | ..... | a 11 | ..... | 9 | ..... | 14 | ..... | ..... | ..... | 27 | ..... | 17 |
| 3 | ..... | 11 | ..... | 10 | ..... | 12 | ..... | ..... | ..... | 23 | ..... | 16 |
| 4 | ..... | 16 | ..... | 10 | ..... | 8 | ..... | ..... | ..... | 20 | ..... | 22 |
| 5 | ..... | ..... | ..... | 11 | ..... | 7 | ..... | ..... | ..... | 15 | ..... | 12 |
| 6 | ..... | ..... | ..... | 15 | ..... | 7 | ..... | ..... | 1.24 | b 13 | 1.14 | a 9.6 |
| 7 | ..... | ..... | 1.39 | b 22.5 | ..... | 7 | ..... | ..... | ..... | 9 | ..... | 8 |
| 8 | ..... | ..... | 1.22 | b 14 | ..... | 6 | 1.55 | a 49 | ..... | 13 | ..... | 7 |
| 9 | ..... | ..... | 1.19 | a 12.5 | 1.00 | b 6.2 | ..... | 45 | ..... | 13 | ..... | 7 |
| 10 | ..... | ..... | ..... | 11 | 1.00 | a 6.2 | 1.69 | b 82 | ..... | 13 | ..... | 15 |
| 11 | ..... | 36 | ..... | 11 | ..... | 6 | ..... | 87 | ..... | 13 | ..... | 100 |
| 12 | ..... | a 52 | ..... | 17 | ..... | 6 | ..... | 60 | ..... | 13 | ..... | 80 |
| 13 | ..... | 40 | ..... | 14 | ..... | 6 | ..... | 50 | 1.24 | b 13 | ..... | 50 |
| 14 | ..... | 30 | ..... | 12 | ..... | 5 | ..... | 40 | 1.34 | a 20 | ..... | 50 |
| 15 | ..... | 24 | ..... | 11 | ..... | 5 | ..... | 34 | ..... | 15 | ..... | 42 |
| 16 | ..... | 28 | 1.11 | b 9.6 | ..... | 5 | 1.45 | b 32 | ..... | 50 | ..... | 14 |
| 17 | ..... | 23 | 1.12 | b 10 | ..... | 5 | ..... | 30 | ..... | 50 | 1.25 | 12.6 |
| 18 | ..... | 19 | ..... | 10 | ..... | 6 | ..... | 34 | ..... | 39 | ..... | 11 |
| 19 | ..... | 16 | ..... | 10 | ..... | ..... | ..... | 40 | ..... | 29 | ..... | 10 |
| 20 | ..... | 16 | ..... | 9 | ..... | ..... | ..... | 46 | ..... | 40 | ..... | 9 |
| 21 | ..... | 18 | ..... | 20 | ..... | ..... | ..... | 55 | ..... | 46 | ..... | 6 |
| 22 | 1.20 | b 13 | ..... | 20 | ..... | ..... | ..... | 44 | ..... | 40 | ..... | 5 |
| 23 | ..... | 21 | ..... | 40 | ..... | ..... | ..... | 35 | ..... | 34 | .99 | b 5 |
| 24 | 1.42 | a 25 | 1.40 | b 23 | ..... | ..... | ..... | 30 | ..... | 40 | ..... | ..... |
| 25 | 1.41 | a 23 | ..... | 21 | ..... | ..... | 1.42 | b 28 | 1.15 | b 9 | ..... | ..... |
| 26 | 1.29 | b 17.5 | ..... | 28 | ..... | ..... | 1.47 | b 35 | 1.47 | b 35 | ..... | ..... |
| 27 | ..... | 16 | ..... | 30 | ..... | ..... | ..... | 34 | ..... | 35 | ..... | ..... |
| 28 | ..... | 14 | ..... | 28 | ..... | ..... | ..... | 31 | ..... | 35 | ..... | ..... |
| 29 | ..... | 11 | 1.44 | b 25.4 | ..... | ..... | ..... | 27 | ..... | 40 | ..... | ..... |
| 30 | ..... | 11 | ..... | 22 | ..... | ..... | 1.44 | a 32 | ..... | 34 | ..... | ..... |
| 31 | ..... | 10 | ..... | 20 | ..... | ..... | ..... | 34 | ..... | 30 | ..... | ..... |
| Mean | ..... | 20.5 | ..... | 16.6 | ..... | 7.6 | ..... | 42.2 | ..... | 27.0 | ..... | 22.8 |
| Run-off per square mile | ..... | 8.20 | ..... | 6.64 | ..... | 3.04 | ..... | 16.9 | ..... | 10.8 | ..... | 9.12 |
| Run-off, depth in inches | ..... | 7.62 | ..... | 7.66 | ..... | 2.10 | ..... | 15.1 | ..... | 12.4 | ..... | 7.80 |

a Measurements.

b Estimates based on gage heights. Other discharges were obtained by plotting a hydrograph passing through the known points and following the rise and fall of Crater Lake outlet, whose basin adjoins that of Thompson Creek and is of a similar character. A measurement on June 25 gave 42 second-feet.

### NUGGET AND COPPER CREEKS.

Nugget Creek rises in the divide between Nome River and Grand Central River and empties its waters and those of its tributary, Copper Creek, into Grand Central River about 2 miles above Salmon Lake.

The headwaters of both Nugget and Copper creeks are precipitous and are fed by springs in limestone. Measurements were made on Nugget Creek at an elevation of 785 feet, at the point where its waters are diverted over the Nugget divide by the Grand Central branch of the Miocene ditch.

During 1907 the discharge of the creek was measured in the ditch about 200 feet below the intake. The results of measurements are given on page 31.

The flow of Copper Creek is also tapped by a branch of the Jett Creek ditch at an elevation of about 800 feet. The combined monthly discharge of Copper and Jett cree' for 1907 is given on page 51.

*Discharge measurements of Nugget and Copper creeks, 1906–7.*

NUGGET CREEK.

[Elevation, 785 feet.]

| Date. | Elevation of point of measurement. | Discharge. | Date. | Elevation of point of measurement. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-feet.* | 1906. | *Feet.* | *Sec.-feet.* |
| June 18 | | 1.8 | August 11 | | 3.0 |
| June 19 | | 1.6 | August 29 | | 8.6 |
| June 21 | | 4.4 | September 2 | | 6.8 |
| June 28 | | .96 | September 7 | | 6.1 |
| July 12 | | 6.8 | September 14 | | 4.4 |

COPPER CREEK.

| | | | | | |
|---|---|---|---|---|---|
| 1906. | | | 1906. | | |
| June 18 | 700 | 3.8 | August 31 | 800 | 6.6 |
| June 19 | 800 | 8.7 | September 10 | 800 | 2.4 |
| June 21 | 700 | 11.6 | | | |
| July 12 | 700 | 11.3 | 1907. | | |
| July 21 | 800 | 2.4 | July 9 | 800 | 9.4 |
| August 11 | 800 | .8 | | | |

*Monthly discharge of Nugget Creek at Miocene intake, 1907.*

[Drainage area, 2.1 square miles.]

| Month. | Discharge in second-feet. | | | Run-off. | |
|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Sec.-ft. per sq. mile. | Depth in inches. |
| July 9–31 | 12.0 | 3.8 | 5.7 | 2.71 | 2.32 |
| August | 10.6 | 2.8 | 6.2 | 2.95 | 3.40 |
| September | 40 | 6.8 | 11.0 | 5.24 | 5.85 |
| 84 days | 40 | 2.8 | 7.8 | 3.71 | 11.57 |

NOTE.—The maximum for September is estimated. For the daily discharge see page 32.

JETT CREEK.

Jett Creek enters Grand Central River from the south. It has a short drainage basin and is made up of a series of falls and rapids. Water is diverted over the Nugget divide into Nome River by the Jett Creek ditch. (See p. 31 for measurements on Jett Creek ditch.)

The discharge of this ditch at times of low water is equal to the combined discharge of Jett and Copper creeks at the intakes, less a small amount of loss by seepage. This has been compared with the natural flow of Nome River for four such periods, as follows:

*Comparison of flow of Jett Creek ditch and Nome River at Miocene intake, 1907.*

| Dates. | Nome River. | Jett and Copper creeks. | Creeks in per cent of Nome River. |
|---|---|---|---|
| | *Sec.-ft.* | *Sec.-ft.* | |
| July 26–31 | 30 | 7.0 | 23 |
| August 1–16 | 22 | 5.2 | 24 |
| August 19–25 | 32 | 7.0 | 22 |
| September 3–8 | 34 | 6.4 | 19 |

The above table shows that the discharge of Jett and Copper creeks was from 24 to 19 per cent of that of Nome River.

The combined discharges of the two creeks for other periods than those given have therefore been taken as 24 per cent of that of Nome River for July, 20 per cent for August, and 16 per cent for September, on the assumption that in September the flow was checked to a greater extent by cold weather than that of Nome River.

Measurements were made in 1906 to show the amount of water available at the diversion.

*Discharge measurements of Jett Creek, 1906.*

[Elevation, 800 feet.]

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Sec.-ft.* | | *Sec.-ft.* |
| June 19 | 14.9 | July 21 | 5.8 |
| July 2 | 4.4 | August 31 | 8.3 |
| July 12 | 14.3 | September 10 | 4.2 |

*Combined monthly discharge of Jett and Copper creeks at Miocene intake, 1907.*

[Drainage area, 2.25 square miles.]

| Month. | Discharge in second-feet. | | | Run-off. | |
|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Sec.-ft. per sq. mile. | Depth in inches. |
| July | 40 | 5.9 | 17.3 | 7.69 | 8.87 |
| August | 15 | 3.9 | 7.1 | 3.16 | 3.64 |
| September | 49 | 2.9 | 9.6 | 4.27 | 4.76 |
| 92 days | 49 | 2.9 | 11.3 | 5.04 | 17.27 |

## MORNING CALL CREEK.

Morning Call Creek enters Grand Central River from the south near Salmon Lake. The hills to the south are lower and more exposed than those of Copper and Jett creeks, and the snow melts earlier in the

spring. At low water all the flow disappears in the pervious limestone above the point where a ditch intended to cross the Nugget divide would have its intake. The water appears again near the contact with the schist, at an elevation of about 750 feet.

*Discharge measurements of Morning Call Creek, 1906.*

| Date. | Elevation of point of measurement. | Discharge. | Date. | Elevation of point of measurement. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| June 20 | 700 | 36 | July 2 | 700 | 10.0 |
| June 20 | 900 | 24.6 | July 12 | 700 | 20.8 |
| June 24 | 500 | 27.3 | August 9 | 900 | 0.0 |

## STORAGE POSSIBILITIES.

There are several reservoir sites in the headwaters of Grand Central River. The most important of these is Crater Lake, which lies in a cirque at an elevation of 973 feet. This lake has an area of 106 acres, and a dam to raise the water 15 feet would increase the area to about 160 acres. The outlet could be arranged so as to draw the lake 5 feet below its present level, thus giving a storage capacity of about 2,500 acre-feet. There is also a small lake at the head of Gold Run. Its area has not been measured, but it would probably afford sufficient storage to reenforce the low-water flow of that stream considerably.

Computations have been made to ascertain the storage capacity that would be necessary to maintain a given discharge in a proposed ditch, taking water either from (1) Gold Run, both forks of Grand Central River, and Thompson Creek; (2) the forks of Grand Central River and Thompson Creek, without Gold Run; or, (3) Gold Run alone, with storage obtained on the lake on that stream. Both 1 and 2 have been studied for a discharge of 80, 100, and 120 second-feet with storage obtained on Crater Lake.

The amount of water that would have to be drawn from storage during any day is the difference between the discharge of the streams tapped and the assumed capacity of the ditch. The sum of these deficiencies for any week or month gives the total draft that would be made on the reservoirs for that period.

The days of deficient flow during 1906 occurred in four periods and those for 1907 in three periods, between which there were periods when the discharge of the streams exceeded the capacity of the ditch. During such periods of greater flow some of the water could be conserved in one of the lakes already mentioned. The amount thus retained would be equal to the excess of the discharge of the streams over the ditch capacity until this excess became greater than the dis-

charge into the lake, or until the lake had refilled or contained enough water to meet any later demands on it. The amount thus conserved during periods of high water, deducted from the total drawn from storage, gives the net storage capacity that would be required. The unit used in the following statement is 1 second-foot for 1 day, which is equal to nearly 2 acre-feet.

*Storage capacity required to maintain given discharges, 1906 and 1907.*

GRAND CENTRAL RIVER, THOMPSON CREEK, AND GOLD RUN.

| Discharge. | July 1 to September 30, 1906. | | | July 8 to September 23, 1907. | | |
|---|---|---|---|---|---|---|
| | Total deficiency. | Storage capacity required. | | Total deficiency. | Storage capacity required. | |
| *Sec.-feet.* | *Sec.-ft. for 1 day.* | *Sec.-ft. for 1 day.* | *Acre-feet.* | *Sec.-ft. for 1 day.* | *Sec.-ft. for 1 day.* | *Acre-feet.* |
| 80 | 127 | 123 | 244 | 9 | 9 | 18 |
| 100 | 560 | 372 | 738 | 51 | 51 | 101 |
| 120 | 1,332 | 1,002 | 1,987 | 274 | 145 | 288 |

GRAND CENTRAL RIVER AND THOMPSON CREEK.

| | | | | | | |
|---|---|---|---|---|---|---|
| 80 | 413 | 268 | 532 | 26 | 26 | 51 |
| 100 | 1,227 | 925 | 1,834 | 212 | 107 | 213 |
| 120 | 2,206 | 1,811 | 3,590 | 607 | 320 | 635 |

GOLD RUN.

| | | | | | | |
|---|---|---|---|---|---|---|
| 20 | 165 | 104 | 206 | 91 | 40 | 79 |
| 25 | 395 | 181 | 359 | 225 | 117 | 232 |
| 30 | 679 | 444 | 880 | 410 | 217 | 430 |

NOTE.—Discharges for the latter part of September, 1906, were estimated.

## SALMON LAKE.

Salmon Lake lies at the foot of the Kigluaik Mountains at an elevation of about 442 feet. It has a water surface area of 1,800 acres and a drainage area of 81 square miles. Its principal supply comes from Grand Central River, which enters it at its west end. A number of small streams also enter the lake from both the north and the south, but with the exception of Fox Creek and Jasper Creek these are of minor importance. The outlet of the lake is through Kruzgamepa River.

This lake offers an excellent opportunity for a storage reservoir for power purposes and mining along Kruzgamepa River. The use of its water in the vicinity of Nome is practically prohibited, owing to its low elevation and the long tunnel which would be necessary to bring the water through the Nugget divide into the Nome River basin. By raising the water of the lake to an elevation of 500 feet the shortest tunnel line would be between 5 and 6 miles long; and if any

allowance be made for drawing on the storage, water could not be brought through to the Nome Valley at an elevation greater than about 450 feet. The mouth of the tunnel would be near Dorothy Creek, and the loss in grade between that point and Nome would bring the water so low that it could not be used to any extent for hydraulicking. Even if the water could be brought to the vicinity of Nome under a sufficient head for hydraulicking, the great cost and difficulty of building so long a tunnel would make the feasibility of the plan very doubtful.

*Measurement of flow in and out of Salmon Lake, 1906.*

| Date. | Stream. | Discharge. |
|---|---|---|
| | | *Sec.-feet.* |
| June 22 | Rainbow Creek | 3.4 |
| Do. | Fox Creek | 99 |
| Do. | 8 small streams from north | *a* 6 |
| June 24 | Jasper Creek | 11.6 |
| Do. | Morning Call Creek | 27 |
| Do. | Jett Creek | *a* 10 |
| Do. | 6 small streams from south | *a* 4 |
| Do. | Grand Central River below Nugget Creek | 313 |
| | Total | 474 |
| June 23 | Kruzgamepa River, at outlet of Salmon Lake | 425 |

*a* Estimated.

NOTE.—The stage of Salmon Lake remained practically constant from June 22 to 24, inclusive.

A measurement on Fox Creek August 16, 1906, gave a discharge of 17.3 second-feet.

## KRUZGAMEPA RIVER DRAINAGE BASIN BELOW SALMON LAKE.

### GENERAL DESCRIPTION.

Kruzgamepa or Pilgrim River, the outlet of Salmon Lake, has a larger discharge than any other stream in this section on which records have been obtained. For about 12 miles it flows in a valley ranging from 6 to 12 miles in width, and then enters the lowlands north of the Kigluaik Range, finally discharging into Imuruk Basin. The principal tributaries are Crater, Grouse, and Homestake creeks from the north and Iron Creek from the south.

As it leaves Salmon Lake the river flows through a narrow outlet having a width of 150 feet at the bottom and 500 feet at the top, offering an excellent dam site and location for a hydro-electric power plant. Plans for the construction of such a plant have been perfected by the Salmon Lake Power Company, which intends to develop 3,000 horsepower, to be used on dredges at Nome and Council and on Solomon River.

Salmon Lake, at its present level, 442 feet, covers 1,800 acres; if raised to a level of 475 feet it would cover 3,600 acres; and at 500 feet, 4,600 acres. The reservoir thus formed could be used for the

storage of the water of the floods caused by the melting snow in the spring and the occasional heavy rains in the summer. The water thus retained would give a large minimum flow not only in summer but also during the winter months, when the natural run-off becomes small.

Kruzgamepa River seldom freezes over before the first of January, and it is probable that with proper installation power could be developed throughout the year.

### KRUZGAMEPA RIVER AT OUTLET OF SALMON LAKE.

A gaging station was established at Leland's camp, about 100 yards below Salmon Lake, June 23, 1906. A temporary gage had been set and float measurements made during the spring flood by J. P. Samuelson.

Discharge measurements were made by wading when the discharge was less than 600 second-feet. The high-water measurements were made by floats in 1906, and from a cable in 1907.

The gage was read twice daily by J. P. Samuelson and M. Donworth.

*Discharge measurements of Kruzgamepa River at outlet of Salmon Lake, 1906–7.*

| 1906. | Area of section. | Mean velocity. | Gage height. | Discharge. | 1907. | Area of section. | Mean velocity. | Gage height. | Discharge. |
|---|---|---|---|---|---|---|---|---|---|
| | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* | | *Sq. ft.* | *Ft. per sec.* | *Feet.* | *Sec.-ft.* |
| June 23 | 183 | 2.32 | 1.22 | 425 | June 16 | 415 | 4.94 | 2.97 | 2,050 |
| June 29 | 170 | 2.08 | 1.00 | 353 | June 17 | 367 | 4.47 | 2.56 | 1,640 |
| June 30 | 157 | 2.01 | .93 | 315 | June 28 | 282 | 3.62 | 1.88 | 1,020 |
| July 9 | 431 | 5.43 | 3.18 | 2,340 | Do | 270 | 3.67 | 1.78 | 991 |
| Do | 412 | 5.09 | 3.02 | 2,094 | July 2 | 248 | 3.03 | 1.56 | 751 |
| July 10 | 372 | 4.73 | 2.68 | 1,760 | July 4 | 220 | 2.58 | 1.30 | 567 |
| August 4 | 117 | 1.81 | .38 | 212 | July 14 | 229 | 2.69 | 1.37 | 616 |
| August 15 | 116 | 1.80 | .37 | 209 | August 2 | 149 | 2.04 | .65 | 304 |
| August 25 | 148 | 2.11 | .70 | 312 | August 14 | 125 | 1.86 | .39 | 232 |
| August 26 | 159 | 2.33 | .80 | 371 | August 23 | 174 | 2.52 | .89 | 438 |
| August 28 | 184 | 2.49 | 1.02 | 458 | September 6 | 155 | 2.13 | .68 | 330 |
| September 1 | 164 | 2.27 | .85 | 373 | September 11 | 362 | 4.20 | 2.52 | 1,520 |
| September 7 | 127 | 1.95 | .52 | 248 | September 12 | 327 | 4.01 | 2.19 | 1,310 |
| September 17 | 108 | 1.62 | .27 | 175 | September 20 | 162 | 2.21 | .76 | 358 |
| September 21 | 336 | 4.61 | 2.38 | 1,546 | | | | | |
| September 23 | 299 | 3.76 | 2.06 | 1,124 | | | | | |
| September 24 | 269 | 3.44 | 1.80 | 925 | | | | | |

*Daily gage height and discharge of Kruzgamepa River at Salmon Lake, 1906.*

[Drainage area, 81 square miles.]

| Day. | May. | | June. | | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 3.05 | 1,780 | 0.82 | 272 | 0.48 | 239 | 0.86 | 387 |
| 2 | | | 3.75 | 2,270 | .72 | 241 | .42 | 221 | .81 | 364 |
| 3 | | | 3.90 | 2,350 | .70 | 235 | .38 | 209 | .74 | 336 |
| 4 | | | 4.20 | 2,520 | .70 | 235 | .36 | 203 | .69 | 316 |
| 5 | | | 3.75 | 2,270 | .80 | 265 | .38 | 209 | .65 | 300 |
| 6 | | | 3.20 | 1,920 | 1.10 | 380 | .38 | 209 | .60 | 280 |
| 7 | | | 2.45 | 1,220 | 1.10 | 380 | .40 | 215 | .53 | 256 |
| 8 | | | | | 1.92 | 1,030 | .40 | 215 | 49 | 242 |
| 9 | | | | | 3.05 | 2,130 | .40 | 215 | .46 | 233 |
| 10 | | | | | 2.60 | 1,640 | .36 | 203 | .41 | 218 |
| 11 | | | | | 2.20 | 1,275 | .35 | 200 | .39 | 212 |

*Daily gage height and discharge of Kruzgamepa River at Salmon Lake, 1906*—Continued.

[Drainage area, 81 square miles.]

| Day. | May. | | June. | | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 12 | | | | | 1.95 | 1,065 | 0.35 | 200 | 0.37 | 206 |
| 13 | | | | | 1.85 | 985 | .36 | 203 | .34 | 197 |
| 14 | | | | | 1.55 | 768 | .34 | 197 | .31 | 188 |
| 15 | | | | | 1.45 | 702 | .36 | 202 | .30 | 185 |
| 16 | | | | | 1.25 | 582 | .35 | 200 | .28 | 180 |
| 17 | | | | | 1.12 | 511 | .32 | 197 | .26 | 175 |
| 18 | | | | | 1.08 | 490 | .30 | 185 | .27 | 178 |
| 19 | | | | | .98 | 441 | .26 | 175 | .52 | 252 |
| 20 | | | | | .90 | 405 | .32 | 191 | 1.34 | 634 |
| 21 | | | | | .82 | 369 | .39 | 212 | 2.35 | 1,410 |
| 22 | | | | | .85 | 382 | .42 | 221 | 2.40 | 1,455 |
| 23 | | | 1.20 | 420 | .82 | 369 | .66 | 304 | 2.11 | 1,198 |
| 24 | | | 1.25 | 442 | .85 | 382 | .71 | 324 | 1.78 | 930 |
| 25 | | | 1.20 | 420 | .82 | 369 | .70 | 320 | 1.58 | 787 |
| 26 | | | 1.12 | 388 | .80 | 360 | .76 | 344 | 1.38 | 658 |
| 27 | | | 1.10 | 380 | .72 | 328 | .90 | 405 | 1.22 | 566 |
| 28 | 5.45 | 3,270 | 1.05 | 360 | .70 | 320 | 1.02 | 460 | 1.08 | 490 |
| 29 | 5.00 | 3,000 | 1.02 | 348 | .62 | 288 | 1.05 | 475 | .98 | 441 |
| 30 | 4.05 | 2,430 | .92 | 308 | .55 | 262 | .99 | 446 | .88 | 396 |
| 31 | 3.60 | 2,180 | | | .50 | 245 | .94 | 423 | | |
| Mean | | 2,720 | | [a] 2,050<br>[b] 383 | | 571 | | 259 | | 456 |
| Run-off per square mile | | 33.6 | | [a] 25.3<br>[b] 4.73 | | 7.05 | | 3.20 | | 5.63 |
| Run-off, depth in inches | | 5.00 | | [a] 6.59<br>[b] 1.41 | | 8.13 | | 3.69 | | 6.28 |
| Run-off, acre-feet | | 21,600 | | [a]28,500<br>[b]6,040 | | 35,100 | | 15,900 | | 27,100 |

[a] June 1 to 7. [b] June 23 to 30.

NOTE.—The channel changed during the high water of July 9, and a new rating table was used after that date. The discharges of May 28 to June 7 are based on measurements which show a low velocity, probably caused by backwater.

*Daily gage height and discharge of Kruzgamepa River at Salmon Lake, 1907.*

[Drainage area, 81 square miles.]

| Day. | June. | | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.70 | 875 | 0.69 | 326 | 1.14 | 522 | 0.30 | 205 |
| 2 | | | 1.58 | 791 | .65 | 312 | 1.00 | 450 | .23 | 188 |
| 3 | | | 1.44 | 696 | .62 | 302 | .90 | 405 | .21 | 182 |
| 4 | | | 1.28 | 599 | .61 | 298 | .82 | 373 | .20 | 180 |
| 5 | | | 1.20 | 555 | .60 | 295 | .77 | 354 | 19 | 178 |
| 6 | | | 1.20 | 555 | .55 | 280 | .73 | 340 | | |
| 7 | | | [a]1.50 | 735 | .48 | 259 | 62 | 302 | | |
| 8 | | | [a]1.45 | 702 | .45 | 250 | .58 | 289 | | |
| 9 | | | [a]1.40 | 670 | .45 | 250 | .71 | 334 | | |
| 10 | | | [a]1.35 | 640 | .44 | 247 | 1.25 | 582 | | |
| 11 | | | [a]1.30 | 610 | .44 | 247 | 2.50 | 1,560 | | |
| 12 | | | [a]1.25 | 582 | .42 | 241 | 2.26 | 1,330 | | |
| 13 | | | [a]1.30 | 610 | .40 | 235 | 1.98 | 1,090 | | |
| 14 | | | 1.35 | 640 | .40 | 235 | 1.59 | 798 | | |
| 15 | 3.30 | 2,360 | 1.26 | 588 | .38 | 229 | 1.40 | 670 | | |
| 16 | 2.99 | 2,040 | 1.15 | 528 | .40 | 235 | 1.26 | 588 | | |
| 17 | 2.47 | 1,530 | 1.10 | 500 | .69 | 326 | 1.10 | 500 | | |
| 18 | 2.72 | 1,770 | 1.02 | 460 | .94 | 423 | .98 | 441 | | |
| 19 | 3.02 | 2,070 | 1.00 | 450 | .97 | 436 | .86 | 389 | | |
| 20 | 2.80 | 1,850 | 1.00 | 450 | .90 | 405 | .74 | 344 | | |
| 21 | 2.32 | 1,390 | 1.18 | 544 | .88 | 397 | .72 | 337 | | |
| 22 | 2.08 | 1,180 | 1.18 | 544 | .90 | 405 | .62 | 302 | | |
| 23 | 2.00 | 1,110 | 1.12 | 511 | .89 | 401 | .54 | 277 | | |
| 24 | 2.08 | 1,180 | 1.08 | 490 | .82 | 373 | .54 | 277 | | |

[a] Estimated.

*Daily gage height and discharge of Kruzgamepa River at Salmon Lake, 1907*—Continued.

| Day. | June. | | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 25 | 2.22 | 1,300 | 1.05 | 475 | 0.78 | 358 | 0.50 | 265 | ..... | ..... |
| 26 | 2.30 | 1,370 | 1.02 | 460 | .80 | 365 | .48 | 259 | ..... | ..... |
| 27 | 2.28 | 1,350 | .98 | 441 | .88 | 397 | .46 | 253 | ..... | ..... |
| 28 | 2.12 | 1,210 | .80 | 365 | .84 | 381 | .42 | 241 | ..... | ..... |
| 29 | 1.95 | 1,070 | .72 | 337 | .86 | 389 | .38 | 229 | ..... | ..... |
| 30 | 1.78 | 935 | .62 | 302 | 1.18 | 544 | .34 | 217 | ..... | ..... |
| 31 | ..... | ..... | .60 | 295 | 1.20 | 555 | ..... | ..... | ..... | ..... |
| Mean | ..... | 1,480 | ..... | 548 | ..... | 335 | ..... | 477 | ..... | 187 |
| Run-off per square mile | ..... | 18.3 | ..... | 6.77 | ..... | 4.14 | ..... | 5.89 | ..... | 2.31 |
| Run-off, depth in inches | ..... | 10.9 | ..... | 7.80 | ..... | 4.77 | ..... | 6.57 | ..... | .43 |
| Run-off, acre-feet | ..... | 47,000 | ..... | 33,700 | ..... | 20,600 | ..... | 28,400 | ..... | 1,850 |

NOTE.—The datum of the 1907 gage was 0.16 foot higher than that of the 1906 gage. The river began to break up May 22, 1907. The discharge increased up to June 15, which was the maximum of the season, and was probably as great during the first half of June as during the last half.

## CRATER CREEK.

Crater Creek is the first large tributary entering Kruzgamepa River from the north. It rises in mountains that reach an elevation of nearly 4,000 feet. The topography and general character of its basin closely resemble those of Grand Central River. (See p. 38.) It drains many small lakes, but none of any considerable size. This stream has good possibilities for water-power development. Measurements were made at an elevation of about 550 feet.

Should developments in the vicinity of Nome ever demand it, the water of Crater Creek could be diverted over the divide into Eldorado River by about 8 miles of ditch and 1.2 miles of siphon across Kruzgamepa River, none of which would be under a pressure of more than 100 feet.

*Discharge measurements of Crater Creek, 1906–7.*

[Elevation, 550 feet.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-feet.* | 1907. | *Feet.* | *Sec.-feet.* |
| August 5 | ..... | 67 | June 29 | 1.80 | 217 |
| August 15 | 0.45 | 57 | July 3 | 1.55 | 131 |
| August 27 | 1.30 | 290 | July 15 | 1.56 | 141 |
| September 1 | .71 | 110 | August 2 | 1.34 | 89 |
| September 8 | .45 | 55 | August 23 | 1.66 | 185 |
| September 16 | .35 | 39 | September 12 | 2.05 | 245 |

## IRON CREEK.

Iron Creek rises in an area of limestone and schist hills of no great elevation lying between Salmon Lake and the headwaters of Casadepaga and Eldorado rivers. It is formed by the junction of Eldorado

and Telegram creeks. Its principal tributaries are Discovery and Canyon creeks, both from the southwest. The portion of the stream above Discovery Creek is sometimes called Dome Creek. Iron Creek empties into Kruzgamepa River about 12 miles below Salmon Lake.

Several mines are being worked successfully on this stream and its tributaries. During 1906 the Gold Beach Development Company built a ditch 13 miles long, which diverts water from Eldorado, Discovery, and Canyon creeks, for use on Discovery, No. 1, and No. 2 claims on Iron Creek.

During 1907 gaging stations were established on Dome Creek below the junction of Eldorado and Telegram creeks, and on Iron Creek below the mouth of Canyon Creek. The gages were read during the low-water period in August by employees of the Gold Beach Development Company.

*Measurements on Iron Creek and tributaries, 1906.*

| Date. | Stream. | Elevation. | Discharge. |
|---|---|---|---|
| | | *Feet.* | *Sec.-feet.* |
| August 14 | Iron Creek | 450 | [a] 17.1 |
| September 15 | do | 425 | [a] 26.1 |
| August 14 | Iron (Dome) Creek | 630 | 6.0 |
| September 15 | do | 630 | 5.0 |
| August 13 | Eldorado Creek | 750 | 4.5 |
| September 15 | do | 750 | 5.6 |
| August 13 | Discovery Creek | 740 | 1.25 |
| September 15 | do | 740 | 2.3 |
| August 13 | Canyon Creek | 760 | 1.3 |
| September 15 | do | 760 | 1.1 |

[a] Below Canyon Creek.

*Discharge measurements of Dome and Iron creeks, 1907.*

DOME CREEK.

[Elevation, 630 feet.]

| Date. | Gage height. | Discharge. |
|---|---|---|
| | *Feet.* | *Sec.-feet.* |
| August 1 | 0.41 | 26 |
| August 22 | .48 | 37 |
| September 18 | .37 | 22 |

IRON CREEK BELOW CANYON CREEK.

[Elevation, 450 feet.]

| | | |
|---|---|---|
| August 1 | 2.09 | 51 |
| August 22 | [a] 1.50 | 99 |
| September 19 | [a] 1.38 | 80 |

[a] New gage.

*Daily gage height and discharge of Dome and Iron creeks, August, 1907.*

| Day. | Dome Creek (drainage area, 20 square miles). | | Iron Creek below Canyon Creek (drainage area, 50 square miles). | | Day. | Dome Creek (drainage area, 20 square miles). | | Iron Creek below Canyon Creek (drainage area, 50 square miles). | |
|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 0.40 | 25 | 2.10 | 52 | 12 | 0.22 | 13 | 1.90 | 33 |
| 2 | .39 | 24 | 2.10 | 52 | 13 | .26 | 15 | 1.90 | 33 |
| 3 | .38 | 23 | 2.10 | 52 | 14 | .26 | 15 | 1.90 | 33 |
| 4 | .37 | 22 | 2.10 | 52 | 15 | .28 | 16 | 2.00 | 41 |
| 5 | .34 | 20 | 2.08 | 50 | 16 | .55 | 54 | 2.18 | 62 |
| 6 | .31 | 18 | 2.08 | 50 | 17 | .70 | 101 | 2.45 | 100 |
| 7 | .30 | 17 | 2.08 | 50 | | | | | |
| 8 | .27 | 15 | 2.05 | 47 | Mean | | 24.5 | | 48.5 |
| 9 | .24 | 14 | 2.02 | 43 | Run-off per square mile | | 1.22 | | .99 |
| 10 | .22 | 13 | 2.00 | 41 | Run-off, in inches | | .77 | | .61 |
| 11 | .20 | 12 | 1.90 | 33 | | | | | |

NOTE.—These discharges are very uncertain, as no measurements were obtained covering the low stages.

## MISCELLANEOUS MEASUREMENTS.

Slate and Willow creeks are tributaries of Kruzgamepa River from the south, 5 or 6 miles below Salmon Lake. Rock Creek is a branch of Slate Creek. These streams will be tapped at an elevation of about 900 feet by a ditch which is being built to work ground on the left bank of Iron Creek. Measurements were made at the proposed intakes.

Pass, Smith, and Grand Union creeks rise on the north side of the Kigluaik Mountains, north of Grand Central River and Gold Run. They are fed by the melting of large banks of snow and have a very steep slope. A project is contemplated for bringing their waters to Coffee and Dahl creeks by means of a pipe line about 18 miles long across the flats of Kruzgamepa and Kuzitrin rivers to Coffee Dome.

*Miscellaneous measurements in Kruzgamepa River drainage basin, 1907.*

| Date. | Stream. | Elevation. | Discharge. |
|---|---|---|---|
| | | *Feet.* | *Sec.-feet.* |
| July 29 | Pass Creek | 620 | 18.1 |
| Do | Smith Creek | 890 | 40 |
| Do | Grand Union Creek | 650 | 12.7 |
| September 19 | Willow Creek | 900 | 3.3 |
| Do | Slate Creek | 900 | 11.3 |
| Do | Rock Creek | 900 | 9.0 |

## IMURUK BASIN DRAINAGE.

The following measurements were made on streams tributary to Imuruk Basin to determine their availability and value for water-power development. They rise on the northerly slope of the northernmost ridge of the Kigluaik Range and are fed by large banks of perpetual snow.

*Measurements on streams tributary to Imuruk Basin, 1906.*

| Date. | Stream. | Elevation. | Drainage area. | Discharge. |
|---|---|---|---|---|
| | | *Feet.* | *Sq. miles.* | *Sec.-feet.* |
| September 5 | Fall Creek | 1,208 | 5 | 34 |
| Do | Glacier Creek | 1,212 | 3 | 10 |
| Do | Snow Gulch | 1,212 | 2 | 9.7 |

## SINUK RIVER DRAINAGE BASIN.

### GENERAL DESCRIPTION.

Sinuk River rises on the southern slope of the Kigluaik Range, adjacent to the headwaters of Grand Central River and Thompson and Buffalo creeks. It flows in a southwesterly direction, entering Bering Sea near Cape Rodney. The upper portion of its drainage basin is mountainous, the greater part of it having an elevation of over 1,000 feet. The upper valley contains a large amount of glacial débris and rock slide. Below the mouth of Stewart River, which is the principal tributary, the valley widens out and is almost flat. The principal tributaries to the upper stream are Windy Creek and the outlet of Glacial Lake from the north and Stewart River from the south.

During 1906 only a few measurements were made and no daily discharge has been computed. A fair estimate of the weekly flow is given on page 72. During 1907 more measurements were made and additional gage readings obtained.

Three plans by which the water from this drainage basin could be brought into the Nome River Valley are outlined in Water-Supply Paper No. 196, pages 38–40. The development of such projects would be very expensive on account of the rocky nature of the ground in the Sinuk drainage basin and the great length of ditch required. The Grand Central River and its tributaries, with their low-water flow reenforced by storage, will probably furnish as much additional water supply as the development of the Nome region will require, and at a smaller cost than that at which it could be obtained from Sinuk River and Windy Creek. If a large body of ground adapted to hydraulic mining should be discovered in the Sinuk Basin itself, the river will furnish a good supply of water at a high level.

### UPPER SINUK RIVER.

The gagings on the upper Sinuk during 1906 and prior to August, 1907, were made at an elevation of 770 feet, and show the probable water supply which could be diverted into Nome River. During August and September, 1907, the gaging station was located about 1½ miles farther downstream, at an elevation of about 700 feet.

*Discharge measurements of upper Sinuk River, 1906.*

[Elevation, 770 feet; drainage area, 6.2 square miles.]

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Sec.-feet.* | | *Sec.-feet.* |
| June 27 | 33 | August 3 | 20 |
| July 6 | 37 | August 10 | 23.5 |
| July 20 | 36 | | |

*Daily gage height and discharge of upper Sinuk River, 1907.*

[Elevation, 700 feet; drainage area, 8.2 square miles.[a]]

| Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|
| | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | |
| | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | |
| 1 | [b]70 | ..... | 36 | ..... | 55 | |
| 2 | 60 | ..... | 35 | 1.38 | [d]46 | |
| 3 | 54 | ..... | 34 | ..... | 40 | |
| 4 | 40 | ..... | 31 | ..... | 50 | |
| 5 | 48 | ..... | 29 | ..... | 40 | |
| 6 | [b]52 | ..... | 26 | 1.32 | [d]33 | |
| 7 | 46 | ..... | 24 | ..... | 30 | |
| 8 | 42 | 1.28 | [c]26 | ..... | 28 | |
| 9 | 42 | ..... | 25 | ..... | 60 | |
| 10 | 60 | ..... | 25 | ..... | 160 | |
| 11 | 80 | ..... | 24 | ..... | 114 | |
| 12 | 70 | 1.27 | [d]24 | ..... | 90 | |
| 13 | [b]75 | ..... | 24 | ..... | 75 | |
| 14 | 62 | ..... | 24 | 1.48 | [c]65 | |
| 15 | 52 | ..... | 22 | ..... | 58 | |
| 16 | 44 | ..... | 60 | ..... | 52 | |
| 17 | 40 | ..... | 100 | ..... | 46 | |
| 18 | 50 | ..... | 82 | 1.41 | [b]41 | |
| 19 | 60 | 1.49 | [c]70 | ..... | 35 | |
| 20 | 80 | ..... | 46 | ..... | 32 | |
| 21 | 100 | ..... | 54 | ..... | 24 | |
| 22 | 60 | ..... | 54 | 1.21 | [c]7 | |
| 23 | 56 | 1.34 | [d]37 | ..... | ..... | |
| 24 | 48 | ..... | 34 | ..... | ..... | |
| 25 | 42 | ..... | 32 | ..... | ..... | |
| 26 | 38 | ..... | 50 | ..... | ..... | |
| 27 | [b]36 | ..... | 62 | ..... | ..... | |
| 28 | 29 | 1.40 | [c]55 | ..... | ..... | |
| 29 | 24 | ..... | 80 | ..... | ..... | |
| 30 | 28 | ..... | 100 | ..... | ..... | |
| 31 | 32 | ..... | 70 | ..... | ..... | |
| Mean | 52.3 | ..... | 45.0 | ..... | 53.7 | |
| Run-off per square mile | 8.44 | ..... | 5.49 | ..... | 6.55 | |
| Run-off, depth in inches | 9.73 | ..... | 6.33 | ..... | 5.36 | |

[a] Elevation, 770 feet, and drainage area, 6.2 square miles during July.
[b] Measurement at elevation, 770 feet.
[c] Measurement at elevation, 700 feet.
[d] Computed from gage reading.
[e] Estimated; slush ice running.

NOTE.—Other discharges were obtained by plotting a hydrograph passing through the known points and following the rise and fall of Nome and Grand Central rivers.

## WINDY CREEK.

Windy Creek, the first large tributary of Sinuk River, lies between the main ridge of the Kigluaik Mountains and the headwaters of the Sinuk. It adjoins West Fork of Grand Central River, from which it may be reached by crossing a high divide. The topography is very rough, the creek being entirely lost in some places in the large bowlders which form its bed.

*Discharge measurements of Windy Creek, 1906.*

| Date. | Elevation at point of measurement. | Discharge. | Date. | Elevation at point of measurement. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| June 21 | 1,000 | 49 | August 3 | 650 | 32 |
| June 27 | 1,100 | 17 | August 10 | 650 | [b] 35 |
| July 13 | [a] 650 | 114 | September 6 | 650 | [b] 32 |
| July 20 | 650 | 48 | | | |

[a] Drainage area, 12 square miles. [b] Estimated.

*Daily gage height and discharge of Windy Creek, 1907.*

[Elevation, 650 feet; drainage area, 12 square miles.]

| Day. | July. | | August. | | September. | | Days. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.36 | [a] 128 | ..... | 60 | ..... | 72 | 20 | ..... | 100 | ..... | 60 | ..... | 40 |
| 2 | ..... | 96 | ..... | 56 | 1.15 | [a] 67 | 21 | ..... | 130 | ..... | 70 | ..... | 30 |
| 3 | ..... | 90 | ..... | 52 | ..... | 56 | 22 | ..... | 80 | ..... | 72 | ..... | [c] 15 |
| 4 | ..... | 100 | ..... | 50 | ..... | 64 | 23 | ..... | 76 | 1.06 | [a] 45 | ..... | ..... |
| 5 | ..... | 112 | ..... | 42 | ..... | 54 | 24 | ..... | 72 | ..... | 42 | ..... | ..... |
| 6 | ..... | 120 | ..... | 34 | 1.05 | [a] 43 | 25 | ..... | 68 | ..... | 40 | ..... | ..... |
| 7 | ..... | 116 | ..... | 32 | ..... | 38 | 26 | ..... | 60 | ..... | 68 | ..... | ..... |
| 8 | ..... | 114 | 1.01 | [b] 35 | ..... | 36 | 27 | 1.13 | [b] 57 | ..... | 80 | ..... | ..... |
| 9 | ..... | 120 | ..... | 34 | ..... | 80 | 28 | ..... | 48 | 1.14 | [b] 70 | ..... | ..... |
| 10 | ..... | 130 | ..... | 34 | ..... | 200 | 29 | ..... | 40 | ..... | 90 | ..... | ..... |
| 11 | ..... | 140 | ..... | 32 | ..... | 140 | 30 | ..... | 50 | ..... | 120 | ..... | ..... |
| 12 | ..... | 125 | 1.00 | [a] 33 | ..... | 110 | 31 | ..... | 56 | ..... | 82 | ..... | ..... |
| 13 | 1.36 | [b] 128 | ..... | 33 | ..... | 90 | | | | | | | |
| 14 | ..... | 105 | ..... | 33 | 1.20 | [a] 79 | Mean | ..... | 91.5 | ..... | 59.2 | ..... | 68.1 |
| 15 | ..... | 85 | ..... | 32 | ..... | 70 | Run-off per square mile | ..... | 7.62 | ..... | 4.93 | ..... | 5.68 |
| 16 | ..... | 74 | ..... | 90 | ..... | 64 | Run-off, depth in inches | ..... | 8.78 | ..... | 5.68 | ..... | 4.65 |
| 17 | ..... | 66 | ..... | 125 | ..... | 56 | | | | | | | |
| 18 | ..... | 70 | ..... | 100 | 1.08 | [a] 50 | | | | | | | |
| 19 | ..... | 80 | 1.21 | [b] 88 | ..... | 45 | | | | | | | |

[a] Computed from gage reading. [b] Measurements. [c] Estimated; slush ice running.

NOTE.—Other discharges were obtained in the same manner as those of Sinuk River.

## NORTH STAR CREEK.

North Star Creek lies between Sinuk River and Windy Creek, and is a tributary to the latter near its mouth. It is a small stream with a steep slope.

*Discharge measurements of North Star Creek, 1906.*

[Elevation, 900 feet; drainage area, 2.3 square miles.]

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Sec.-ft.* | | *Sec.-ft.* |
| June 27 | 9.8 | July 20 | 3.9 |
| July 6 | 18.1 | August 3 | 3.0 |
| July 13 | 16.4 | August 10 | 2.9 |

*Daily gage height and discharge of North Star Creek, 1907.*

[Elevation, 900 feet; drainage area, 2.3 square miles.]

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | 1.36 | [a] 28 | ..... | 8 | ..... | 7 | 20 | ..... | 24 | ..... | 7 | ..... | 4 |
| 2 | ..... | 20 | ..... | 7 | 0.92 | [b] 4.5 | 21 | ..... | 30 | ..... | 8 | ..... | 3 |
| 3 | ..... | 16 | ..... | 7 | ..... | 4 | 22 | ..... | 20 | ..... | 8 | .75 | [c] 2.0 |
| 4 | ..... | 13 | ..... | 6 | ..... | 7 | 23 | ..... | 16 | .97 | [b] 5.2 | ..... | ..... |
| 5 | ..... | 14 | ..... | 5 | ..... | 6 | 24 | ..... | 13 | ..... | 5 | ..... | ..... |
| 6 | 1.26 | [a] 16 | ..... | 5 | .94 | [b] 4.8 | 25 | ..... | 10 | ..... | 4 | ..... | ..... |
| 7 | ..... | 14 | ..... | 4 | ..... | 4 | 26 | ..... | 8 | ..... | 8 | ..... | ..... |
| 8 | ..... | 13 | 0.94 | [a] 4.8 | ..... | 4 | 27 | 1.03 | [a] 5.5 | ..... | 12 | ..... | ..... |
| 9 | ..... | 14 | ..... | 5 | ..... | 4 | 28 | ..... | 5 | 1.13 | [a] 9.1 | ..... | ..... |
| 10 | ..... | 16 | ..... | 5 | ..... | 40 | 29 | ..... | 4 | ..... | 14 | ..... | ..... |
| 11 | ..... | 20 | ..... | 5 | ..... | 30 | 30 | ..... | 5 | ..... | 20 | ..... | ..... |
| 12 | ..... | 22 | .97 | [b] 5.3 | ..... | 20 | 31 | ..... | 6 | ..... | 10 | ..... | ..... |
| 13 | 1.33 | [a] 23 | ..... | 5 | ..... | 14 | | | | | | | |
| 14 | ..... | 17 | ..... | 5 | 1.08 | [b] 7.8 | Mean | ..... | 14.8 | ..... | 8.3 | ..... | 8.9 |
| 15 | ..... | 14 | ..... | 5 | ..... | 7 | Run-off per square mile | ..... | 6.43 | ..... | 3.61 | ..... | 3.87 |
| 16 | ..... | 12 | ..... | 15 | ..... | 7 | Run-off, depth in inches | ..... | 7.41 | ..... | 4.16 | ..... | 3.16 |
| 17 | ..... | 10 | ..... | 25 | ..... | 6 | | | | | | | |
| 18 | ..... | 13 | ..... | 16 | 1.00 | [b] 5.7 | | | | | | | |
| 19 | ..... | 17 | 1.10 | [a] 8.3 | ..... | 5 | | | | | | | |

[a] Measurements. [b] Computed from gage reading. [c] Estimated: slush ice running.

NOTE.—Other discharges were obtained in the same manner as those of Sinuk River.

## STEWART RIVER.

Stewart River lies south of upper Sinuk River, to which it is tributary. It drains an area of limestone and schist hills. The flow is small and the stream of minor importance.

*Discharge measurements of Stewart River, 1906.*

[Elevation, 400 feet.]

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Sec.-ft.* | | *Sec.-ft.* |
| July 15 | 72 | July 30 | [a] 26 |
| July 17 | 49 | August 19 | 11.4 |

[a] Estimated.

## SLATE CREEK.

Slate Creek is the second tributary to Stewart River from the north. The following measurements give approximately the flow that can be diverted into Nome River over Divide Creek:

*Discharge measurements of Slate Creek, 1906.*

[Elevation, 700 feet; drainage area, 2.1 square miles.]

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Sec.-ft.* | | *Sec.-ft.* |
| July 15 | 6.7 | July 30 | 2.8 |
| July 17 | 4.4 | August 19 | 2.2 |

### OTHER SINUK RIVER DRAINAGE.

For measurements on Josie, Irene, and Jessie creeks, which are small tributaries of Stewart River, see "Cedric ditch."

## CRIPPLE RIVER DRAINAGE BASIN.

### GENERAL DESCRIPTION.

Cripple River enters Bering Sea about 12 miles west of Nome, and drains an area of about 88 square miles. As yet but little mining has been done in this section, except in the vicinity of Oregon and Hungry creeks. Some small ditches have been constructed at the headwaters of Cripple River, the principal one being the Cedric, which diverts water from the Stewart River drainage area.

### CEDRIC DITCH.

#### GENERAL DESCRIPTION.

The Cedric ditch was built in 1905 to divert water from Josie and Jessie creeks (tributary to Stewart River) over the divide to the Cripple River basin for use on Oregon, Hungry, Trilby, and Nugget creeks. After passing the divide it picks up water from upper Oregon (two forks), Slate, and Aurora creeks, which are its principal feeders, and from Daisy Swift Creek, Snowshoe Gulch, and three other small gulches. It has a total length of about 19 miles and a width of 4 to 8 feet. The elevation of the head is about 870 feet and of the outlet 790 feet. The capacity of the lower half is about 25 second-feet. Water is carried across Oregon Creek near the outlet by a syphon 2,970 feet long, of 30-inch riveted steel pipe. There are about 6 miles of distributing ditches at the lower end.

The following measurements were made to determine the amount of water available for the ditch:

*Water available for Cedric ditch, 1906–7.*

| Stream. | 1906. | | | 1907. |
|---|---|---|---|---|
| | July 15–17. | July 30–31. | August 19. | August 31. |
| | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* |
| Josie Creek | 3.0 | 1.5 | 1.1 | [a]2.0 |
| Irene Creek | 1.0 | [a].8 | [a].4 | [a]3.0 |
| Jessie Creek | [b]3.2 | 2.6 | .6 | [a]3.0 |
| Upper Oregon Creek | [b]6.8 | 2.6 | ..... | [a]3.5 |
| Slate Creek | 4.0 | 2.0 | ..... | 3.1 |
| Aurora Creek | 4.8 | 2.1 | ..... | 2.4 |
| Daisy Swift Creek | .5 | ..... | ..... | ..... |
| Total available for ditch | 18.3 | 11.6 | ..... | 17.0 |

[a]Estimated.
[b]Measured below ditch level; only about half this amount is available for the ditch.

*Seepage measurements on Cedric ditch, 1906.*

| Date. | Point of measurement. | Discharge. | Loss. | Distance. | Loss per mile. |
|---|---|---|---|---|---|
| | | *Sec.-ft.* | *Sec.-ft.* | *Miles.* | *Sec.-ft.* |
| July 30 | Below upper Oregon Creek | 2.6 | | | |
| Do | Above Slate Creek | 1.9 | 0.7 | 2.3 | 0.3 |
| Do | Below Slate Creek | 3.9 | | | |
| July 31 | Above Aurora Creek | 3.1 | .8 | 1.8 | .4 |
| Do | Below Aurora Creek | 5.2 | | | |
| Do | Above Daisy Swift Creek | 4.7 | .5 | 2.0 | .25 |
| Do | Below Daisy Swift Creek | 4.5 | .2 | .6 | .3 |
| Do | At penstock | 2.5 | 2.0 | 3.7 | .5 |
| | | | 4.2 | 10.4 | .4 |

CEDRIC DITCH ABOVE PENSTOCK.

This station was established to determine the total flow of the ditch. The gage was located just above the penstock of the siphon across Oregon Creek. Part of the water was used in a giant connected with the bottom of the siphon and part was used for hydraulicking about one-fourth mile above the siphon.

*Discharge measurements of Cedric ditch above penstock, 1907.*

| Date. | Above penstock. | | Discharge to upper giant. |
|---|---|---|---|
| | Gage height. | Discharge. | |
| | *Feet.* | *Sec.-ft.* | *Sec.-ft.* |
| July 22 | 0.80 | 10.3 | 3.0 |
| August 30 | .78 | 8.6 | 4.4 |
| August 31 | .76 | 7.9 | 5.0 |
| September 19 | .10 | 0 | |

*Daily gage height and discharge of Cedric ditch above penstock, 1907.*

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.00 | 13.1 | 0.95 | 12.2 | 18 | | | 1.08 | 14.6 | 1.05 | 14.0 |
| 2 | | | 1.02 | 13.5 | .85 | 10.2 | 19 | | | 1.15 | 16.0 | | 0 |
| 3 | | | 1.02 | 13.5 | .98 | 12.7 | 20 | | | 1.08 | 14.6 | | 0 |
| 4 | | | 1.05 | 14.0 | .88 | 10.8 | 21 | | | 1.10 | 15.0 | | 0 |
| 5 | | | .95 | 12.2 | .95 | 12.2 | 22 | 0.80 | 9.3 | 1.10 | 15.0 | | 0 |
| 6 | | | .88 | 10.8 | .95 | 12.2 | 23 | .88 | 10.8 | .95 | 12.2 | .65 | 6.6 |
| 7 | | | .80 | 9.3 | .98 | 12.7 | 24 | 1.00 | 13.1 | .95 | 12.2 | .68 | 7.1 |
| 8 | | | .92 | 11.6 | .95 | 12.2 | 25 | .98 | 12.7 | 1.05 | 14.0 | .60 | 5.7 |
| 9 | | | .90 | 11.2 | 1.05 | 14.0 | 26 | 1.00 | 13.1 | 1.20 | 16.9 | .60 | 5.7 |
| 10 | | | .90 | 11.2 | 1.20 | 16.9 | 27 | .90 | 11.2 | 1.10 | 15.0 | .62 | 6.1 |
| 11 | | | .88 | 10.8 | 1.25 | 17.8 | 28 | .88 | 10.8 | 1.05 | 14.0 | .58 | 5.4 |
| 12 | | | .90 | 11.2 | 1.15 | 16.0 | 29 | 1.00 | 13.1 | 1.00 | 13.1 | .52 | 4.5 |
| 13 | | | .95 | 12.2 | 1.05 | 14.0 | 30 | 1.10 | 15.0 | .85 | 10.2 | .50 | 4.2 |
| 14 | | | .98 | 12.7 | 1.02 | 13.5 | 31 | 1.05 | 14.0 | .80 | 9.3 | | |
| 15 | | | .98 | 12.7 | 1.10 | 15.0 | | | | | | | |
| 16 | | | 1.05 | 14.0 | 1.02 | 13.5 | Mean | | 12.3 | | 12.9 | | 9.6 |
| 17 | | | 1.05 | 14.0 | 1.05 | 14.0 | | | | | | | |

## PENNY RIVER DRAINAGE BASIN.

### GENERAL DESCRIPTION.

Penny River rises about 13 miles from the seacoast and enters Bering Sea about 10 miles west of Nome. Its basin lies between Snake and Cripple rivers and has a total area of 36 square miles. Two ditches have been built by the United Mining Company. The Sutton ditch has its intake one-half mile above the mouth of Willow Creek and extends about 6 miles to a point near the mouth of Jess Creek. The water is used for hydraulicking on the second beach line, which lies about 1,200 feet back of the present beach. The Highline ditch, uncompleted, has its intake 7 miles above the Sutton ditch and will extend to Sunset Creek, a distance of about 11 miles. The water is carried across Honey Creek in a pipe line 2,000 feet long.

### PENNY RIVER AT SUTTON INTAKE AND SUTTON DITCH.

Gaging stations were established on Sutton ditch and Penny River just below the ditch intake, and the sum of the discharges gives the natural flow of the river at this point. The gages were read by employees of the United Mining Company.

*Discharge measurements of Penny River and Sutton ditch at intake, 1906–7.*

PENNY RIVER.

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| 1906. | *Feet.* | *Sec.-ft.* | 1907. | *Feet.* | *Sec.-ft.* |
| August 1 | | 6.2 | July 4 | .82 | 12.6 |
| | | | July 22 | 1.30 | 42 |
| 1907. | | | September 1 | .99 | 16.3 |
| July 4 | 1.11 | 31 | | | |

SUTTON DITCH.

| | | | | | |
|---|---|---|---|---|---|
| 1906. | | | 1907. | | |
| August 1 | | 30 | July 4 | 1.49 | 44 |
| | | | July 22 | 1.11 | 25 |
| 1907. | | | September 1 | 1.32 | 38 |
| July 4 | 1.20 | 28 | | | |

*Daily gage height and discharge of Penny River and Sutton ditch at intake, 1907.*

| Day. | July. | | | | August. | | | | September. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | River. | | Ditch. | | River. | | Ditch. | | River. | | Ditch. | |
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | 71 | ..... | 29 | ..... | 85 | ..... | 0 | 1.0 | 19 | 1.3 | 35 |
| 2 | ..... | 56 | ..... | 29 | ..... | 85 | ..... | 0 | 1.0 | 19 | 1.3 | 35 |
| 3 | ..... | 41 | ..... | 29 | ..... | 85 | ..... | 0 | 1.0 | 19 | 1.3 | 35 |
| 4 | 1.1 | 26 | 1.2 | 29 | ..... | 85 | ..... | 0 | 1.0 | 19 | 1.3 | 35 |
| 5 | 1.1 | 26 | 1.2 | 29 | ..... | 85 | ..... | 0 | .9 | 14 | 1.3 | 35 |
| 6 | 1.3 | 44 | 1.25 | 32 | 1.6 | 79 | 0.8 | 9 | .9 | 14 | 1.3 | 35 |
| 7 | 2.2 | 152 | 1.2 | 29 | 1.4 | 55 | .8 | 9 | .9 | 14 | 1.3 | 35 |
| 8 | 1.6 | 79 | 1.2 | 29 | 1.1 | 26 | 1.0 | 18 | .9 | 14 | 1.3 | 35 |
| 9 | 1.3 | 44 | 1.25 | 32 | 1.1 | 26 | 1.0 | 18 | 1.0 | 19 | 1.3 | 35 |
| 10 | 1.3 | 44 | 1.2 | 29 | .8 | 10 | 1.2 | 29 | 2.1 | 140 | 1.3 | 35 |
| 11 | 1.3 | 44 | 1.2 | 29 | .8 | 10 | 1.2 | 29 | 1.8 | 103 | 1.3 | 35 |
| 12 | 1.2 | 34 | 1.2 | 29 | .7 | 7 | 1.2 | 29 | 1.6 | 79 | 1.3 | 35 |
| 13 | 1.4 | 55 | 1.2 | 29 | .7 | 7 | 1.2 | 29 | 1.0 | 19 | 1 3 | 35 |
| 14 | 1.5 | 67 | 1.2 | 29 | .7 | 7 | 1.2 | 29 | 1.0 | 19 | 1.3 | 35 |
| 15 | 1.2 | 34 | 1.1 | 23 | .6 | 4 | 1.2 | 29 | 1.8 | 103 | .5 | 0 |
| 16 | 1.2 | 34 | 1.1 | 23 | 1.4 | 55 | 1.2 | 29 | 1.8 | 103 | .5 | 0 |
| 17 | 1.2 | 34 | 1 1 | 23 | 1.2 | 34 | 1.2 | 29 | 1.7 | 91 | .8 | 9 |
| 18 | 1.2 | 34 | 1.1 | 23 | 1.1 | 26 | 1.2 | 29 | 1.3 | 44 | 1.3 | 35 |
| 19 | 1.5 | 67 | 1.1 | 23 | .9 | 14 | 1.25 | 32 | 1 3 | 44 | 1 3 | 35 |
| 20 | 1.3 | 44 | 1.1 | 23 | .8 | 10 | 1.3 | 35 | 1.3 | 44 | 1.3 | 35 |
| 21 | 1.5 | 67 | 1 1 | 23 | 1.0 | 19 | 1.25 | 32 | 1.3 | 44 | 1.3 | 35 |
| 22 | 1.3 | 44 | 1.1 | 23 | .9 | 14 | 1.25 | 32 | 1.2 | 34 | 1.3 | 35 |
| 23 | 1.2 | 34 | 1.1 | 23 | .8 | 10 | 1.3 | 35 | 1.1 | 26 | 1.3 | 35 |
| 24 | 1.4 | 55 | 1.1 | 23 | .8 | 10 | 1.3 | 35 | 1.1 | 26 | 1.3 | 35 |
| 25 | 1.4 | 55 | 1.0 | 18 | 1.0 | 19 | 1.5 | 47 | 1.1 | 26 | 1.3 | 35 |
| 26 | 1.6 | 79 | 1.0 | 18 | 1.3 | 44 | 1.2 | 29 | 1.1 | 26 | 1.3 | 35 |
| 27 | 1.5 | 67 | 1.0 | 18 | 1.3 | 44 | 1.2 | 29 | 1.0 | 19 | 1.3 | 35 |
| 28 | 1.5 | 67 | 1.0 | 18 | 1.3 | 44 | 1 2 | 29 | .9 | 14 | 1.3 | 35 |
| 29 | 1.4 | 55 | .9 | 13 | 1.2 | 34 | 1.2 | 29 | .9 | 14 | 1.3 | 35 |
| 30 | 1.5 | 67 | .8 | 9 | 1.2 | 34 | 1.2 | 29 | .8 | 10 | 1.3 | 35 |
| 31 | 1.6 | 79 | .7 | 6 | 1.1 | 26 | 1.2 | 29 | ..... | ..... | ..... | ..... |
| Mean | ..... | 54.8 | ..... | 23.9 | ..... | 35.3 | ..... | 23.8 | ..... | 33.9 | ..... | 31.8 |

*Monthly discharge of Penny River at Sutton intake, 1907.*

[Drainage area, 19 square miles.]

| Month. | Discharge in second-feet. | | | Run-off. | |
|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Sec.-ft. per sq. mile. | Depth in inches. |
| July | 181 | 55 | 78.7 | 4.14 | 4.77 |
| August | 88 | 33 | 59.0 | 3.11 | 3.58 |
| September | 175 | 45 | 71.1 | 3.74 | 4.17 |
| 92 days | 181 | 33 | 69.6 | 3.66 | 12.52 |

NOTE.—These values are the sum of the discharges of Sutton ditch and of Penny River below the ditch intake.

*Discharge measurements of Penny River at Highline intake, 1906–7.*

| Date. | Discharge. | Per cent of Sutton intake. | Date. | Discharge. | Per cent of Sutton intake. |
|---|---|---|---|---|---|
| 1906. | *Sec.-ft.* | | 1907. | *Sec.-ft.* | |
| August 1 | 7.8 | 22 | July 22 | 15.9 | 24 |
| | | | August 30 | 15.6 | 28 |

## SNAKE RIVER DRAINAGE BASIN.

### GENERAL DESCRIPTION.

Snake River empties into Bering Sea at Nome. It has a drainage area of 110 square miles, which contains some of the richest mining ground in Seward Peninsula, notably the claims on Glacier, Anvil, and Little creeks. Owing to its slight fall the use of the main stream for mining purposes is limited to ground sluicing. All the available water from its tributaries is being used, and water is diverted into this area by the Miocene ditch, the Seward ditch, and the Nome River ditch of the Pioneer Mining Company.

### SNAKE RIVER ABOVE GLACIER CREEK.

A station was established June 25, 1907, just above the mouth of Glacier Creek, to determine the discharge of this stream and the relation of the run-off from its drainage basin to that from areas in and near the Kigluaik Mountains. The run-off per square mile during the period covered by the records was 56 per cent of that of Nome River and 38 per cent of that of Kruzgamepa River.

The gage was read by A. H. Clambey.

*Discharge measurements of Snake River above Glacier Creek, 1907.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| June 25 | 1.88 | 527 | August 10 | .89 | 72 |
| July 3 | 1.20 | 168 | September 3 | 1.01 | 112 |
| July 20 | 1.13 | 147 | | | |

*Daily gage height and discharge of Snake River above Glacier Creek, 1907.*

[Drainage area, 69 square miles.]

| Day. | June. | | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.35 | 235 | 1.05 | 120 | 1.08 | 129 |
| 2 | | | 1.30 | 212 | 1.02 | 111 | 1.05 | 120 |
| 3 | | | 1.25 | 191 | 1.00 | 105 | 1.05 | 120 |
| 4 | | | 1.18 | 163 | 1.00 | 105 | 1.05 | 120 |
| 5 | | | 1.22 | 178 | .96 | 94 | 1.04 | 117 |
| 6 | | | 1.32 | 221 | .95 | 91 | 1.03 | 114 |
| 7 | | | 1.50 | 308 | .96 | 94 | 1.02 | 111 |
| 8 | | | 1.35 | 235 | .94 | 89 | 1.08 | 129 |
| 9 | | | 1.25 | 191 | .92 | 83 | 1.08 | 129 |
| 10 | | | 1.25 | 191 | .92 | 83 | 1.15 | 152 |
| 11 | | | 1.28 | 204 | .91 | 80 | 1.90 | 540 |
| 12 | | | 1.25 | 191 | .90 | 77 | 1.68 | 408 |
| 13 | | | 1.20 | 170 | .98 | 99 | 1.52 | 319 |
| 14 | | | 1.20 | 170 | .97 | 97 | 1.47 | 293 |
| 15 | | | 1.18 | 163 | .90 | 77 | 1.50 | 308 |
| 16 | | | 1.10 | 135 | 1.04 | 117 | | |
| 17 | | | 1.12 | 142 | 1.10 | 135 | | |
| 18 | | | 1.10 | 135 | 1.10 | 135 | | |
| 19 | | | 1.18 | 163 | 1.05 | 120 | | |
| 20 | | | 1.18 | 163 | 1.00 | 105 | | |
| 21 | | | 1.20 | 170 | 1.05 | 120 | | |
| 22 | | | 1.18 | 163 | 1.01 | 108 | | |
| 23 | | | 1.16 | 156 | .99 | 102 | | |
| 24 | | | 1.22 | 178 | 1.00 | 105 | | |

*Daily gage height and discharge of Snake River above Glacier Creek, 1907*—Continued.

| Day. | June. | | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 25 | 1.90 | 540 | 1.30 | 212 | 1.02 | 111 | ..... | ..... |
| 26 | 1.85 | 510 | 1.22 | 178 | 1.08 | 129 | ..... | ..... |
| 27 | 1.80 | 480 | 1.18 | 163 | 1.10 | 135 | ..... | ..... |
| 28 | 1.55 | 335 | 1.12 | 142 | 1.10 | 135 | ..... | ..... |
| 29 | 1.45 | 283 | 1.08 | 129 | 1.10 | 135 | ..... | ..... |
| 30 | 1.40 | 258 | 1.08 | 129 | 1.10 | 135 | ..... | ..... |
| 31 | ..... | ..... | 1.05 | 120 | 1.08 | 129 | ..... | ..... |
| Mean | ..... | 401 | ..... | 177 | ..... | 108 | ..... | 207 |
| Run-off per square mile | ..... | 5.81 | ..... | 2.56 | ..... | 1.56 | ..... | 3.00 |
| Run-off, depth in inches | ..... | 1.30 | ..... | 2.95 | ..... | 1.80 | ..... | 1.67 |

## FLAMBEAU AND ELDORADO RIVER DRAINAGE BASINS.

Flambeau and Eldorado rivers rise near Salmon Lake and flow in a southerly direction to Bering Sea near Cape Nome.

The Flambeau Hastings ditch has its intake on the upper fork of Flambeau River and is to be built to Hastings Creek, near Cape Nome. Another ditch to Hastings Creek is projected, which will divert the water to Eldorado River below Venetia Creek, and will have a length of over 30 miles. The following measurements were made at the proposed intake of this ditch: August 14, 1906, 44 second feet; September 17, 1907, 225 second feet.

## SOLOMON RIVER DRAINAGE BASIN.

Solomon River empties into Bering Sea at Solomon, 40 miles east of Nome. This stream has been a good producer of gold, and several ditches have been built to utilize its water and that of its tributaries, including the East Fork ditch of the Solomon River Hydraulic Company, the Midnight Sun ditch from Big Hurrah Creek, the Brogan ditch from the mouth of Johns Creek to East Fork, and a ditch about 7 miles long on Coal Creek.

A ditch has been started by the Three Friends Mining Company to furnish power for its dredge on Solomon River. It will take water from the river just below East Fork and extend to a point below the mouth of Shovel Creek, where a head of 75 feet will be available.

*Discharge measurements in Solomon River drainage basin, 1907.*

| Date. | Stream and locality. | Drainage area. | Discharge. |
|---|---|---|---|
| | | *Sq. miles.* | *Sec.-ft.* |
| October 1 | Solomon River below Johns Creek | 66 | 43 |
| Do | Brogan ditch at intake | ..... | 7.7 |
| | | | 50.7 |
| October 2 | Solomon River below East Fork | 40 | 96 |
| Do | East Fork ditch | 10 | 17 |
| | | | 113 |

## FLOW OF DITCHES IN NOME REGION.

The following table has been prepared to show in a concise manner the flow of the ditches which take their water supply from Nome River and its tributaries, and from near-by streams. It is also of value for comparison with the discharge of the streams from which the water is taken, to show the percentage of flow that can be delivered by a ditch at the point where it is to be used.

*Monthly discharge of ditches in Nome region, 1907.*

| Ditch. | Point of measurement. | Yearly maximum. | July | | August. | September. |
|---|---|---|---|---|---|---|
| | | *Sec.-ft.* | *Days.* | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* |
| Campion | Black Point | 18.0 | 25 | 9.0 | 12.9 | 12.5 |
| Miocene | do | 42.6 | 29 | 28.0 | 34.4 | 38.7 |
| Do | Clara Creek | 37.0 | 29 | 25.4 | 28.7 | 33.7 |
| Do | Above Hobson | 34.9 | 29 | 23.6 | 27.4 | 31.8 |
| Do | Below Hobson | 54.7 | 31 | 43.8 | 45.3 | 47.9 |
| Do | Flume | 55.2 | 31 | 45.1 | 44.0 | 50.4 |
| Do | David Creek branch | 16.5 | 15 | 11.3 | 11.8 | 9.0 |
| Do | Jett Creek branch | 8.2 | 20 | 4.9 | 6.1 | [a] 6.1 |
| Do | Grand Central branch | 13.4 | 23 | 5.7 | 6.2 | 9.0 |
| Seward | Nome River intake | 29.0 | 21 | 23.9 | 26.2 | 25.7 |
| Do | Hobson Creek branch | | 26 | 5.2 | 4.3 | 4.5 |
| Pioneer | Nome River intake [b] | 26.8 | 16 | 20.4 | 22.2 | 21.8 |
| Do | Hobson Creek branch | | | | | 5.8 |
| Sutton | Intake | 35.0 | 31 | 23.9 | 23.8 | 31.8 |
| Cedric | Penstock | 17.8 | 10 | 12.3 | 12.9 | 9.6 |

[a] Mean for 14 days.
[b] Values for Pioneer ditch have been estimated at 85 per cent of those for Seward ditch; this was the proportion during the time for which records were obtained on both ditches.

## AVAILABLE WATER SUPPLY DURING 1906 AND 1907.

In order to show the amount of water that was available during 1906 and 1907 for hydraulicking the placers near Nome, the mean flow of the streams in each drainage basin has been tabulated by weekly periods in the table on page 72. In using this table the following points should be noted :

The "Nome River high-level flow" represents the total amount of water in that river above the Miocene ditch, including the flow of the Campion ditch, David Creek, and Hobson Creek. The flow of the springs on Hobson creek has been taken as 14 second-feet during 1906 except for the first week in July, when it did not exceed 10 second-feet.

The "Nome River low-level flow" includes all additional water down to Pioneer ditch. The drainage area of Nome River below the Miocene and David Creek intakes and above the Pioneer intake is 18 square miles. The run-off from this area for the period in August, 1907, during which records were kept was at about the same rate per square mile as at the Miocene intake. The low-level flow has therefore been taken as 1.2 times the natural flow at the Miocene intake, where the drainage area is 15 square miles. To this has been

added 60 per cent of the discharge of Hobson Creek at the Miocene intake, this being approximately the amount entering that stream between the Miocene and Pioneer intakes.

"Upper Grand Central River," etc., includes the station below the forks and those on Thompson Creek and Gold Run, and gives the amount that can be brought over the Nugget divide.

The mean flow of "Nugget, Copper, and Jett creeks" gives the amount that can be brought over the Nugget divide, and for 1906 was estimated from the few measurements obtained.

The flow of "Sinuk River, Windy and North Star creeks," has been estimated for an elevation of 800 feet, which is as low as the water can be taken over the divide into Nome River. The amount of this flow for 1906 was obtained by taking 70 per cent of the flow of Grand Central River below the forks, this precentage being determined as follows:

*Comparison of flow of Grand Central River below forks with that of Sinuk River and its tributaries at elevation of 800 feet.*

| Date. | Sinuk River. | Windy Creek. | North Star Creek. | Total. | Grand Central below forks. | Sinuk, Windy, and North Star in per cent of Grand Central. |
|---|---|---|---|---|---|---|
| | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* | |
| June 26, 27 | 33 | 22 | 10 | 65 | 105 | 62 |
| July 6 | 37 | (35) | 18 | 90 | ..... | ..... |
| July 13 | (75) | 86 | 16 | 177 | 198 | 89 |
| July 20 | 36 | 36 | 4 | 76 | 100 | 76 |
| August 3 | 20 | 24 | 3 | 47 | 67 | 70 |
| August 10 | 23.5 | 26 | 3 | 52.5 | 65 | 81 |
| September 6 | (20) | 24 | (3) | 47 | 67 | 70 |

The drainage area of Grand Central River lies on the north side of a ridge of the Kigluaik Mountains, and the basins of Sinuk River and Windy and North Star creeks lie adjacent to it on the south side of the same ridge. On the days when measurements of flow were made of the streams on both sides of the mountains it was found, as shown in the preceding table, that the flow on the south side was from 62 to 89 per cent of the flow on the north side. It is, therefore, conservative to say that the average combined flow of Sinuk River and Windy and North Star creeks was 70 per cent of the flow of Grand Central River below the forks.

During the season of 1907 gaging stations were maintained on all the streams which are summarized below, and their daily discharge is given elsewhere.

The following table should not be taken as indicating the water that can be used. This will, of course, be limited by the capacity of ditches that can be built economically. In the economical construction of a ditch the size will depend largely upon the duration of the

low-water flow. This will probably limit the size in most cases to twice the minimum, except for short ditches.

*Mean weekly water supply, in second-feet, available for use back of Nome, 1906–1907.*

| Date. | Available for use at elevation 220 to 280 feet. | Available for use at elevation 400 to 450 feet. | | | | Total. |
|---|---|---|---|---|---|---|
| | Nome River low-level flow. | Nome River high-level flow. | Upper Grand Central, Thompson, and Gold Run. | Nugget, Copper, and Jett creeks. | Sinuk River, Windy and North Star creeks. | |
| 1906. | | | | | | |
| July 1–7 | 43 | 45 | 153 | 7 | 88 | 324 |
| July 8–14 | 155 | 144 | [a]343 | 26 | 173 | 796 |
| July 15–21 | 52 | 58 | 179 | 15 | 90 | 378 |
| July 22–28 | 43 | 49 | 156 | 12 | 79 | 325 |
| July 29–August 4 | 36 | 42 | 101 | 8 | 50 | 223 |
| August 5–11 | 39 | 45 | 108 | 8 | 49 | 236 |
| August 12–18 | 49 | 53 | 91 | 8 | 42 | 228 |
| August 19–25 | 81 | 84 | 138 | 10 | 62 | 352 |
| August 26–September 1 | 130 | 128 | 202 | 22 | 94 | 540 |
| September 2–8 | 68 | 73 | 101 | 14 | 51 | 287 |
| September 9–18 | 48 | 53 | 68 | 9 | 36 | 199 |
| September 19–30 | 120 | 118 | 250 | 20 | 125 | 599 |
| Mean | 72 | 74 | 158 | 13 | 78 | 375 |
| Maximum | 155 | 144 | 343 | 26 | 173 | 796 |
| Minimum | 36 | 42 | 68 | 7 | 36 | 199 |
| 1907. | | | | | | |
| July 1–7 | 135 | 199 | [b] | 36 | 152 | 522 |
| July 8–14 | 102 | 152 | 292 | 27 | 172 | 745 |
| July 15–21 | 84 | 107 | 228 | 21 | 143 | 583 |
| July 22–28 | 60 | 77 | 183 | 15 | 105 | 440 |
| July 29–August 4 | 44 | 59 | 144 | 11 | 77 | 335 |
| August 5–11 | 36 | 49 | 107 | 8 | 50 | 250 |
| August 12–18 | 49 | 62 | 190 | 13 | 95 | 409 |
| August 19–25 | 47 | 61 | 245 | 15 | 86 | 454 |
| August 26–September 1 | 72 | 89 | 318 | 18 | 124 | 621 |
| September 2–8 | 51 | 63 | 142 | 14 | 72 | 342 |
| September 9–15 | 176 | 204 | 418 | 40 | 167 | 1,005 |
| September 16–23 | 60 | 76 | 115 | 24 | 62 | 337 |
| September 24–30 | 45 | 56 | [b] | 15 | [b] | 116 |
| Mean | 74 | 96 | 216 | 20 | 109 | 473 |
| Maximum | 176 | 204 | 418 | 40 | 172 | 1,005 |
| Minimum | 36 | 49 | 107 | 8 | 50 | 116 |

[a] Too small, no record of highest water.
[b] No record. No water could have been used from Grand Central River the first week in July, on account of snow; nor from either Grand Central or Sinuk rivers the last week in September, on account of ice.

## DITCH AND PIPE LINES.

In order to bring the water to the gold-producing ground between Capes Nome and Rodney at sufficient elevation to be used for hydraulicking and sluicing, nearly 300 miles of ditch and pipe line have been constructed and several extensive additional systems are now under construction or consideration. The first ditch in this section was built in 1901, by Leland, Davidson, and Bliss, from upper Glacier Creek to Snow Gulch. This ditch demonstrated the practicability of ditch systems in this country and was the beginning of the Miocene system.

Ditches are usually built so as to follow the contour approximately with grades limiting the velocity to about 2 feet per second, which is as high as the material in this section will stand without scour. The ditches are therefore for the most part on slopes, and are constructed by making a cut from 12 to 18 inches deep to grade at the lower bank. This bank is then built up by material from the excavation. The slopes of the banks are from 1:1 to 1½:1, depending on the material.

The work of constructing a ditch is usually divided into three classes—team work, pick and shovel work, and rock work. Teams may be used in handling dry soil that contains only medium-sized rock. This is the fastest method, and the compacting of the lower banks by the horses and scrapers makes it much tighter than when the dirt is thrown in loose. Pick and shovel are used in loose rock, in wet soil, and in frozen ground from which the top is removed as it thaws from the surface. Rock must be blasted, unless it is fissured limestone, which may be loosened with the crowbar, or decomposed schist, which yields to the pick. In building through solid rock, a shelf is blasted out about 1 foot below grade and wide enough to carry the ditch and the lower bank, which is built of rocks. The bottom and sides are lined with sod about 1 foot thick, and are puddled with clay. In rock slide the method is similar. A good example of this kind of construction was seen on the Grand Central branch of the Miocene system. The ditch was built through a pile of large bowlders, unmixed with any soil or gravel. A trench was made 1 foot deeper and 2 feet wider than the finished ditch. The sides of the trench were lined with a slope wall, laid 1 to 1, to a height of 4 or 5 feet. The outer slope of the lower bank was also rock wall, laid somewhat flatter. The ditch will be lined with sod and will be tight and permanent.

The use of sod is very common and economical, and saves much piping and fluming that would otherwise be necessary. The sod in a short time settles and knits together, and thus becomes a very serviceable bank. It will not cut or wear out, and the older it gets the better it becomes. In this way a ditch can be made over perpetually frozen ground, where otherwise it would be impossible. Much ditch has to be constructed over loose stones with little or no sediment between them. Such ditches must be lined with sod and all holes must be filled by tamping sod into them as far as possible. This being done, it will be found that the water traveling through the ditch will deposit sediment over the sod and that after a little while it will become tight.

Canvas is also used as a lining to make a ditch water-tight. Willows with the tops left out, so that they may grow, are utilized in embankments with success.

In construction over "glacier," which is the term used for frozen muck mixed with ground ice, the ditch is either built wholly on top of the sod covering or an excavation is made and lined with sod. Ditches over this material are expensive to maintain, owing to the thawing of the ice by the running water.

One of the most interesting pieces of construction over glacier is the flume on the Miocene ditch. This flume is 1,100 feet long, and has a width of 8 feet and a depth of 28 inches. It was constructed in 1901, and is now in practically perfect alignment, both horizontal and vertical, and no repairs have been necessary on it. In putting in the foundation, trenches were dug 3 or 4 feet deep in the frozen ground, which was practically all ice. The excavated material was covered to protect it from thawing. A sill was laid in the bottom of the trench and the uprights fastened to this sill. The excavated material was then replaced in the trenches and froze again into the original condition. Sod was carefully placed over the trench. The uprights were then sawed off to grade and the flume constructed on them.

Inverted siphons are built across deep ravines where their use will save expense and reduce loss by seepage. Most of these are riveted steel pipe. Joints are made by lapping the ends from 4 to 6 inches. Siphons must be weighted down and protected by rock to prevent injury by frost and snowslides. During 1906 two siphons were built on the Seward ditch, across Clara and Hobson creeks, continuous wood-stave pipes with steel bands being used.

On account of the rapid surface run-off during hard rains, it is necessary to have waste gates at short intervals. The most common waste gates consist either of a flume as deep as the bottom of the ditch, in which the height of the water is regulated by flashboards, or of a long weir, laid on the ground surface, which will spill the water when it reaches a certain level.

Ditch intakes consist of a dam or barrier across the stream, containing one or more waste gates, and head gates for regulating the flow into the ditch. In order to divert the entire flow of a stream, a bed-rock dam must be built to stop the ground flow through the gravelly beds. Such a dam is made by cutting a trench across the stream bed, extending down to an impervious stratum, and filling it with sod, which is carefully laid and tamped. The dam should be protected from erosion with large flat rocks or riprap.

Frozen ground, inadequate facilities for transportation, and the high cost of help[a] and supplies make ditching very expensive. To the first cost of a ditch should be added the cost of maintenance for the first three years, during which time extensive repairs are neces-

[a] Laborers receive $5 per day and board; blacksmiths, cooks, etc., $6.

sary. On many ditches these repairs cost as much as the first construction. At the end of three years ditches are, as a rule, in fairly permanent condition and the cost of maintenance is greatly reduced. Such information as could be obtained shows that the cost of a ditch carrying from 1,000 to 2,000 inches, including the first three years' maintenance, is from $5,000 to $10,000 per mile. Owing to dangers from washouts and landslides it is necessary to have the ditch constantly patrolled.

Owing to the frozen condition of the ground it is not practicable to use ditches much before the 1st of July, as the surface does not become fully thawed until that time, and during the thawing period the ground becomes very soft and there is great danger of damage by washouts.

The following table gives a list of the principal ditches in this region. Some of the data given are only approximate, as it was necessary to obtain them by inquiry.

*Ditches between Cape Nome and Cape Rodney, Seward Peninsula.*

| Name. | From— | To— | Length. | Date completed. | Bottom width | Fall per mile. | Capacity. | Elevation. Head. | Elevation. Outlet. |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Miles.* | | *Feet.* | *Feet.* | *Sec.-feet.* | *Feet.* | *Feet.* |
| Miocene Ditch Co.: | | | | | | | | | |
| Main ditch | Nome River | Hobson Creek | 13 | 1903 | 8 | 4.5 | 40 | 572 | 500 |
| | Hobson Creek | The Ex | 14 | 1902 | 10 | 3.37 | 55 | 500 | 445 |
| | The Ex | Snow Gulch | 4 | 1901 | 8 | 6.5 | 55 | 445 | 420 |
| Feeding laterals. | Upper Glacier Creek | The Ex | 2 | 1901 | | | 6 | | 445 |
| | Grouse Creek | Flume | 4 | | | | 10 | | 478 |
| | Upper New Eldorado Creek. | Buster Creek | 10 | 1907 | | | 6 | 742 | |
| | David Creek | Nome River above main intake. | 1.8 | 1905 | 5 | 5.28 | 18 | 590 | 580 |
| | Jett Creek | Nugget Divide. | 3.5 | 1906 | 3.5 | 6 | 10 | 806 | 785 |
| | Grand Central River. | do | 8 | (a) | 8–10 | 5 | 80 | 850 | 785 |
| Distributing laterals. | The Ex | Grass Gulch | 4 | | 6 | 3.17 | 16 | 445 | 432 |
| | New Year Gulch. | Cooper Gulch | 4 | 1907 | 8 | 5.28 | 40 | 417 | 396 |
| Tunnel | Kanoma Gulch, Glacier Creek | New Year Gulch, Anvil Creek. | b 1,800 | 1904 | c 4x7 | | | 420 | 417 |
| Wild Goose Mining and Trading Co.: | | | | | | | | | |
| Seward | Nome River below Dorothy Creek. | Anvil Creek | 38 | 1906 | 10 | 3.17 | 32 | 408 | 274 |
| Pipe line | Crater Lake | Nugget Divide. | 8 | (a) | d 42 | 15 | 60 | 963 | |
| | Nugget Divide. | Anvil Mountain. | 35 | (a) | d 48 | 10 | 70 | | |
| | Pumping plant. | do | 7 | | d 18 | | 6 | | |
| | No. 3, below Little Creek. | Pumping plant. | 3 | 1902 | 4 | 5.3 | 6 | | |
| Pioneer Mining Co.: | | | | | | | | | |
| South bank | No. 2, above Anvil Creek. | No. 1, below Anvil Creek. | 0.75 | 1902 | 5 | 7 | 4–6 | | |
| North bank | No. 4, above Anvil Creek. | Moonlight Reservoir. | 1.25 | 1903 | 6 | | 10–12 | | |
| | Nome River, above Clara Creek. | Little Creek | 38 | 1907 | 8 | 3.17 | 30 | 320 | 200 |

a Under construction.
b Feet.
c Cross section.
d Diameter in inches.

*Ditches between Cape Nome and Cape Rodney, Seward Peninsula*—Continued.

| Name. | From— | To— | Length. | Date completed. | Bottom width. | Fall per mile. | Capacity. | Elevation. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Head. | Outlet. |
| | | | *Miles.* | | *Feet.* | *Feet.* | *Sec.-feet.* | *Feet.* | *Feet.* |
| United Ditch Co.: | | | | | | | | | |
| Sutton | Penny River | Beach | 6 | 1905 | 20–15 | 3.12 | 40 | 120 | 90 |
| Highline | do | Sunset Creek | 10.5 | (a) | 7 | 4.22 | ..... | 420 | ..... |
| Miscellaneous: | | | | | | | | | |
| Cedric | Josie Creek | Hungry Creek | 19 | 1905 | 4–8 | 4 | 25 | 870 | 790 |
| Campion | Buffalo | Dorothy Creek | 4 | 1903 | 6 | 7.5 | 28 | 610 | 580 |
| Peninsula Hydraulic Co. | New Eldorado Creek. | Osborn Creek | 9 | 1907 | 14 | ..... | 50 | ..... | ..... |
| Northland Mining Co. | Gold bottom Creek. | Balto Creek | 12 | (a) | ..... | ..... | 20 | 390 | ..... |
| Hot Air | Divining | Glacier Creek, opposite Snow Gulch. | 6 | 1902 | ..... | ..... | 10 | ..... | ..... |
| Price and Tremper. | Glacier Creek | Opposite Snow Gulch. | 2.5 | ..... | ..... | ..... | 5 | 175 | ..... |
| Golden Dawn. | Twin Mountain Creek. | Alpha Creek | 10 | (a) | ..... | ..... | 20 | 500 | ..... |
| Corson Mining Co. | Last Chance Creek. | Pioneer Gulch | 4 | 1903 | ..... | ..... | 18 | 460 | ..... |
| Plein | No. 7, Otter Creek. | Mouth | 1 | 1904 | ..... | ..... | 3 | ..... | ..... |
| Flambeau Hastings. | Head of Flambeau River. | Hastings Creek | 29 | 1906 | ..... | ..... | 20 | ..... | ..... |
| Capt. Peterson. | No. 3, below Anvil Creek | Little Creek | 2.5 | ..... | ..... | ..... | 16 | ..... | ..... |
| Cripple River Hydraulic Mining Co. | West bank Cripple River | Fox Gulch | 11 | (a) | 8–10 | 4 | 50 | ..... | ..... |
| Jourden-Cummings. | Buffalo Creek | Boer Creek | 4 | 1906 | 4 | 6 | 10 | 1,000 | ..... |

a Under construction.

## WATER-POWER POSSIBILITIES.

Owing to the great value of water in this region for use in working the auriferous gravels but little attention has been given to power development. In various portions of the peninsula there are, however, excellent power sites whose development is feasible from both an engineering and a financial standpoint. The scarcity of fuel makes steam power very expensive, and it is probable that much of the future mining, especially along the tundra back of Nome and along the larger streams, will be carried on by dredging or by some form of elevating in which power will play an important part. With this in view, the attention of capitalists should be directed to the consideration of power possibilities.

Work has been begun at Salmon Lake on the construction of a dam. (See p. 54.) The Three Friends Mining Company has started a ditch on Solomon River to develop power for its dredge.

Many streams in the Kigluaik Mountains, notably the glacier-fed torrents on their northern slope, are available for developments under a high head.

# THE KOUGAROK REGION.

By Fred F. Henshaw.

## INTRODUCTION.

In 1907 the investigation of streams begun the previous year in the Nome region was extended to the Kougarok region. Owing to the large area that had to be covered and the lack of railroad or other transportation facilities only a few regular stations were maintained, and on most of the streams only a few discharge measurements were made. The work was carried on by the writer, who was in this district from July 15 to September 18.

In the present report the name Kougarok region is used to include not only most of the Kougarok precinct, but parts of the adjoining Port Clarence and Goodhope precincts. The drainage basin of Kruzgamepa River, though included in the Kougarok precinct, has already been considered with the Nome region, with which it more naturally falls.

A summary of the records in this region is combined with one for the Nome region (see p. 95), in order to afford a comparison of conditions in the two districts.

## DESCRIPTION OF AREA.

The Kougarok region lies northeast of the Kigluaik Mountains, in the central portion of Seward Peninsula. It is about 50 miles square, embracing the drainage basin of Kougarok River and parts of the adjoining basins of Noxapaga, Serpentine, and American rivers.

Most of this area is comprised in an upland which represents a former level of erosion. The flat-topped ridges of the hills lie at an elevation of 1,000 to 1,600 feet. Several mountain masses rise above the level of the plateau, notably Kougarok, Midnight, and Baldy mountains. Into this plateau the river channels are deeply cut. The streams flow in steep canyons, above which one or more levels of benches can usually be traced. The rivers drain southward into the Kuzitrin, which flows through the broad lowland basin separating this region from the Kigluaik Mountains.

The general slope of the rivers from source to mouth is more uniform than in the Nome region. The fall occurs mostly in riffles separated by pools of slack water. The stream beds are narrower and have shallower gravel deposits than most of the streams south of the mountains. (See Pl. VIII, *A*, p. 80.)

A large portion of the area, probably 40 to 60 per cent, is underlain with frozen muck and ground ice, which was observed in some places to have a thickness of 25 to 30 feet. This is covered with moss, and unless exposed by stripping never thaws deeper than a few inches.

## CONDITIONS AFFECTING WATER SUPPLY.

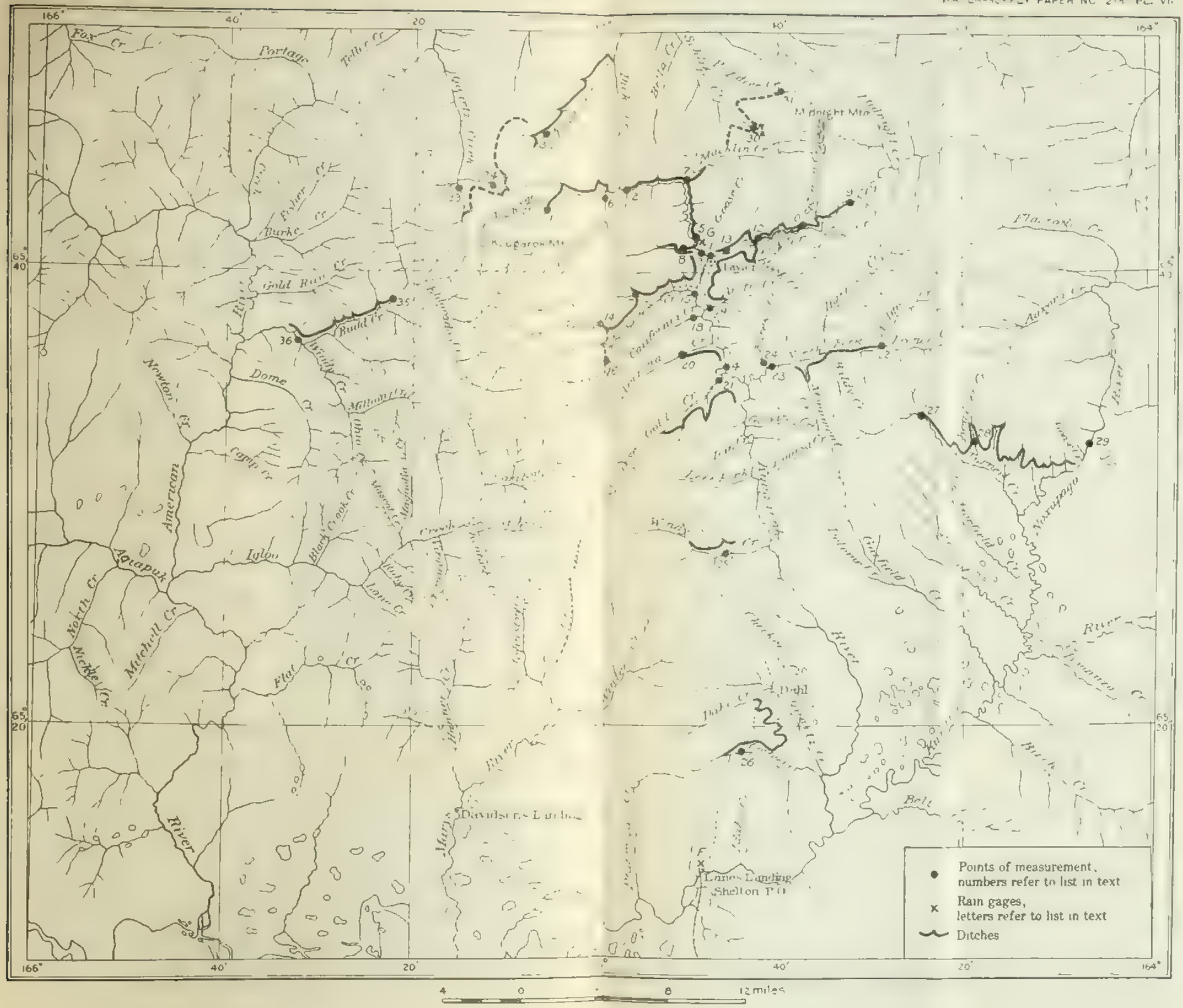
In general the water supply of the Kougarok region comes from the same sources as that of the Nome region, namely, summer rains, melting of snow, and melting of frozen ground.

The difference in rainfall between this area and that south of the mountains is striking. The totals of 2.51 and 2.79 inches for Shelton and Taylor, respectivly, are only about one-sixth of the total at Grand Central and only one-third to one-half of those of the other three rainfall stations. (See p. 137.) The Kougarok region is in a measure cut off from the comparatively abundant rainfall of the Nome region by the Kigluaik Mountains. This high and steep range causes most of the moisture from the southerly winds to be precipitated on its southern slope, leaving little to be carried into the region farther north. The northerly winds bring heavy clouds and fog banks from the Arctic Ocean, but they yield little rain.

In 1907 there was no rain in this region until the middle of July and very little until a month later, so that the run-off up to August 1 came mostly from melting snow. During the three weeks of extremely low water that followed the water must have been derived from the melting of the ground and the snow banks that still remained, partly from springs, and only to a slight degree from the rainfall.

The ground is all frozen muck, and is so protected by moss that it never thaws more than a few inches. There can be no regulation of flow by ground storage, therefore, and the rain finds its way into the streams immediately after it falls. This effect is more marked here than in the Nome region. Thus, on July 24, 1907, the flow of Taylor Creek rose from 10 to 186 second-feet in two or three hours, and four days later had fallen again to about 13 second-feet.

But little definite information can be obtained in regard to climatic conditions in former years in the Kougarok region. The last season was one of drought in that region, whereas the water supply south of the mountains was plentiful. The most reliable information that could be obtained was to the effect that the low-water periods of 1900




MAP SHOWING LOCATION OF GAGING STATIONS AND DITCHES IN KOUGAROK REGION

and 1906 were fully as long and as severe as that of 1907. During the week of August 10 to 16, 1907, the flow at all the gaging stations remained nearly constant, and was probably as low as it would have become had the weather continued dry, as practically all the water must have come from springs and from the melting snow. Whenever there occurs a period of two weeks or more in midsummer without rain, the flow is likely to become as small as in 1907.

### GAGING STATIONS.

The following is a list of the points in the Kougarok region at which gages were established or discharge measurements made in 1907. The numbers refer to Pl. VII.

*Gaging stations in Kougarok region.*

1. Kougarok River below Washington Creek, Washington Creek, and Irving ditch.
2. Kougarok River at Homestake intake and Homestake ditch.
3. Kougarok River above Taylor Creek.
4. Kougarok River above Coarse Gold Creek.
5. Homestake ditch at penstock.
6. Columbia Creek.
7. Macklin Creek.
8. Homestake Creek.
9. Taylor Creek at North Star intake.
10. Taylor Creek at Cascade intake.
11. Taylor Creek at mouth.
12. North Star ditch above siphon.
13. Cascade ditch.
14. Henry Creek at ditch intake.
15. Henry Creek at mouth.
16. Lincoln Creek at ditch level.
17. Lillian Creek.
18. California Creek.
19. Arctic Creek.
20. Arizona Creek.
21. Coarse Gold Creek.
22. North Fork at Northwestern intake.
23. North Fork above Eureka Creek.
24. Eureka Creek.
25. Windy Creek and ditch.
26. Coffee Creek and ditch.
27. Turner Creek at McKays intake.
28. Boulder Creek.
29. Noxapaga River above Goose Creek.
30. Schlitz Creek.
31. Reindeer Creek.
32. Bryan Creek.
33. Quartz Creek.
34. Bismark Creek.
35. Budd Creek spring.
36. Budd Creek below Windy Creek.

## KOUGAROK RIVER DRAINAGE BASIN.

### DESCRIPTION OF BASIN.

Kougarok River drains a large area lying in the central portion of Seward Peninsula and empties into the Kuzitrin about 8 miles above Lanes Landing. It rises southeast of Kougarok Mountain and flows northward, then eastward, and after making a sharp bend to the right flows a little east of south to its mouth. The largest tributaries are Taylor Creek and North Fork from the east, and Henry, Coarse Gold, and Windy creeks from the west. Of less importance are Washington, Columbia, Macklin, Homestake, Goose, California,

Arctic, Arizona, Louisa, Galvin, and Dan creeks, and Left Fork. Quartz Creek, which empties into the river below those named above, and its tributaries, Coffee, Dahl, Checkers, Carrie, and Independence creeks, have been the most important gold producers of the region, but have a very small run-off except at times of heavy rain.

### KOUGAROK RIVER BELOW WASHINGTON CREEK.

The following measurements were made to determine the water supply available for the ditch of the Irving Mining Company, which is about 200 feet higher than the Homestake ditch: July 27, 4.5 second-feet; August 12, 2.2 second-feet; September 9, 122 second-feet.

### KOUGAROK RIVER AT HOMESTAKE INTAKE AND HOMESTAKE DITCH.

These stations are located about 100 yards below the intake of Homestake ditch (see Pl. VIII, *A*), and the sum of their discharges gives the total flow of the river at this point. The gage was read by employees of the Kugarok Mining and Ditch Company.

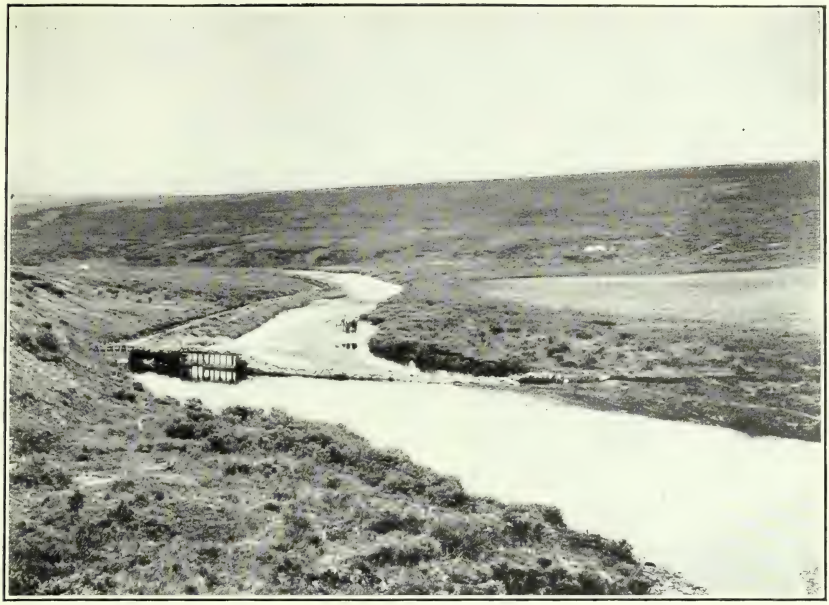
*Discharge measurements of Kougarok River at Homestake intake and Homestake ditch, 1907.*

KOUGAROK RIVER.

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| July 15 | 1.24 | 18.0 | August 22 | 1.64 | 82 |
| Do | 1.13 | 6.6 | September 1 | .89 | .5 |
| July 20 | 1.08 | 2.0 | September 4 | 1.34 | 42 |
| August 9 | .92 | 3.1 | September 10 | 2.47 | 303 |
| August 12 | .90 | 2.2 | September 11 | 1.98 | 153 |
| August 19 | .92 | 3.3 | | | |

HOMESTAKE DITCH.

| | | | | | |
|---|---|---|---|---|---|
| July 15 | 0.51 | 11.6 | August 19 | 0.28 | 7.4 |
| Do | .45 | 10.2 | Do | .27 | 7.3 |
| Do | —.05 | .4 | August 22 | .62 | 17.6 |
| July 20 | .36 | 8.1 | Do | .75 | 23.0 |
| July 29 | .20 | 5.7 | September 10 | .44 | 12.0 |
| August 12 | —.04 | 1.5 | | | |



*A*. INTAKE OF HOMESTAKE DITCH ON KOUGAROK RIVER.

*B*. HOMESTAKE DITCH, SHOWING SOD WORK.

*Daily gage height and discharge of Kougarok River at Homestake intake and Homestake ditch, 1907.*

| Day. | July. | | | | August. | | | | September. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | River. | | Ditch. | | River. | | Ditch. | | River. | | Ditch. | |
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | ..... | ..... | ..... | 0.4 | 0.25 | 6.8 | 1.01 | 10.8 | 0.62 | 17.8 |
| 2 | ..... | ..... | ..... | ..... | ..... | .4 | .15 | 4.8 | 1.15 | 22 | .66 | 19.4 |
| 3 | ..... | ..... | ..... | ..... | ..... | .4 | .18 | 5.3 | 1.12 | 20 | .68 | 20.2 |
| 4 | ..... | ..... | ..... | ..... | ..... | .4 | .32 | 8.5 | 1.35 | 42 | .64 | 18.6 |
| 5 | ..... | ..... | ..... | ..... | ..... | .4 | .28 | 7.5 | 1.57 | 71 | .58 | 16.3 |
| 6 | ..... | ..... | ..... | ..... | ..... | .4 | .20 | 5.7 | 1.44 | 53 | .64 | 18.6 |
| 7 | ..... | ..... | ..... | ..... | ..... | .4 | .16 | 4.9 | 1.28 | 35 | .64 | 18.6 |
| 8 | ..... | ..... | ..... | ..... | ..... | .4 | .10 | 3.8 | 1.16 | 23 | .65 | 19.0 |
| 9 | ..... | ..... | ..... | ..... | 0.92 | 3.2 | .06 | 3.2 | 1.78 | 110 | .69 | 20.6 |
| 10 | ..... | ..... | ..... | ..... | .90 | 2.2 | −.02 | 2.0 | 2.56 | 336 | .55 | 15.2 |
| 11 | ..... | ..... | ..... | ..... | .90 | 2.2 | −.03 | 1.8 | 1.86 | 124 | .62 | 17.8 |
| 12 | ..... | ..... | ..... | ..... | .90 | 2.2 | −.04 | 1.7 | 1.54 | 67 | .65 | 19.0 |
| 13 | ..... | ..... | ..... | ..... | .89 | 1.7 | −.06 | 1.5 | 1.33 | 40 | .66 | 19.4 |
| 14 | ..... | ..... | ..... | ..... | .90 | 2.2 | −.06 | 1.5 | 1.17 | 24 | .66 | 19.4 |
| 15 | 1.24 | 18 | ..... | 0 | .91 | 2.7 | −.08 | 1.2 | 1.74 | 99 | .66 | 19.4 |
| 16 | ..... | 3.0 | ..... | 13.0 | .91 | 2.7 | −.08 | 1.2 | 1.50 | 61 | .68 | 20.2 |
| 17 | ..... | 3.0 | ..... | 12.0 | .91 | 2.7 | +.04 | 2.8 | 1.22 | 29 | .69 | 20.6 |
| 18 | ..... | 3.0 | ..... | 10.0 | .92 | 3.2 | .12 | 4.2 | 1.11 | 18.9 | .70 | 21.0 |
| 19 | ..... | 3.0 | ..... | 9.0 | .92 | 3.2 | .28 | 7.5 | 1.04 | 13.2 | .62 | 17.8 |
| 20 | 1.08 | 2.9 | 0.36 | 8.0 | .91 | 2.7 | .18 | 5.3 | 1.10 | 18.6 | .30 | 8.0 |
| 21 | 1.05 | 2.0 | .40 | 9.0 | 1.40 | 48 | .60 | 17.0 | ..... | ..... | ..... | ..... |
| 22 | 1.04 | 1.6 | .31 | 6.7 | 1.71 | 93 | .61 | 17.4 | ..... | ..... | ..... | ..... |
| 23 | 1.00 | .4 | .34 | 7.4 | 1.58 | 72 | .61 | 17.4 | ..... | ..... | ..... | ..... |
| 24 | 1.20 | 14.0 | .62 | 15.4 | 1.17 | 24 | .63 | 18.2 | ..... | ..... | ..... | ..... |
| 25 | 1.03 | 1.3 | .55 | 15.2 | 1.54 | 67 | .58 | 16.3 | ..... | ..... | ..... | ..... |
| 26 | 1.00 | .4 | .49 | 13.2 | 1.28 | 35 | .59 | 16.6 | ..... | ..... | ..... | ..... |
| 27 | .88 | .4 | .42 | 11.1 | 1.22 | 29 | .66 | 19.4 | ..... | ..... | ..... | ..... |
| 28 | .89 | 4 | .26 | 7.1 | 1.09 | 17 | .62 | 17.8 | ..... | ..... | ..... | ..... |
| 29 | ..... | .4 | .22 | 6.2 | .96 | 5.8 | .61 | 17.4 | ..... | ..... | ..... | ..... |
| 30 | ..... | .4 | .21 | 5.9 | .95 | 5.0 | .69 | 20.6 | ..... | ..... | ..... | ..... |
| 31 | ..... | .4 | ..... | 6.4 | .89 | .5 | .57 | 16.0 | ..... | ..... | ..... | ..... |
| Mean | ..... | 3.2 | ..... | 9.2 | ..... | 13.9 | ..... | 8.9 | ..... | 60.8 | ..... | 18.3 |

NOTE.—Discharges for July 16 to 19 are estimated. All water was carried in the ditch from July 26 to August 8, inclusive, except the seepage through the diversion dam, which was estimated. During this time about 2 second-feet was turned out of the first waste gate to furnish a sluice head for operators who were working in the river bed below.

*Monthly discharge of Kougarok River at Homestake intake, 1907.*

[Drainage area, 44 square miles.]

| Month. | Discharge in second feet. | | | Run-off. | |
|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Sec.-ft per sq. mile. | Depth in inches. |
| July 15–31 | 29 | 6.3 | 12.4 | 0.28 | 0.18 |
| August | 110 | 3.2 | 22.8 | .52 | .60 |
| September 1–20 | 351 | 26 | 79.1 | 1.80 | 1.34 |
| 68 days | 351 | 3.2 | 36.8 | .84 | 2.12 |

NOTE.—These values include the discharge of both the river and Homestake ditch, as given in the previous table.

### KOUGAROK RIVER ABOVE TAYLOR CREEK.

The following measurements were made just above the mouth of Taylor Creek, to compare the flow of the two forks at their junction, and to determine the discharge available for a ditch at this level: July 26, 18.5 second-feet; July 29, 8 second-feet; August 10, 5.1 second-feet.

### KOUGAROK RIVER ABOVE COARSE GOLD CREEK.

Between the mouths of Taylor Creek and North Fork, Kougarok River has a meandering course, with well-marked benches along most of the distance. At the mouth of Coarse Gold Creek it makes a bend which brings two points more than 2 miles apart by river within 560 feet of each other in a straight line. A tunnel through this neck would drain the gravels in this stretch of river bed and make them accessible for working, and would also render available a considerable water power. The difference in level of the water surface at the two ends of the tunnel is about 17 feet. An outcrop of rock which crosses the river just below the proposed tunnel intake would make a fairly good dam site. A gaging station was established at this point July 15, 1907. The gage was located just above the rock outcrop mentioned above, where the channel is permanent, and was read by William Ellis. The bench mark is a cross on the highest point of a rock near the left bank, about 200 feet above the tunnel entrance; elevation, 2.18 feet above the datum of the 1907 gage.

The discharge at this station also gives the water supply that would be available for a low-line ditch to Dahl Creek. Such a ditch is proposed. It will have its intake on Kougarok River below Dreamy Gulch and on Henry Creek near the mouth, and will extend to Dahl and Coffee creeks, a distance of over 30 miles. Only a small percentage of the water enters the river between these proposed intakes and the gaging station.

*Discharge measurements of Kougarok River above Coarse Gold Creek, 1907.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| July 14 | 1.11 | 89 | August 8 | 0.44 | 19 |
| July 21 | .86 | 51 | August 14 | .40 | 17 |
| July 23 | .74 | 36 | August 23 | 2.22 | 460 |
| July 30 | .64 | 33 | August 26 | 1.95 | 323 |

*Daily gage height and discharge of Kougarok River above Coarse Gold Creek, 1907.*

[Drainage area, 250 square miles.]

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | 0.70 | 35 | ..... | 210 | 19 | 0.90 | 54 | 1.12 | 92 | ..... | 160 |
| 2 | ..... | ..... | .63 | 31 | ..... | 230 | 20 | .84 | 47 | 1.08 | 84 | ..... | 130 |
| 3 | ..... | ..... | .60 | 29 | ..... | 205 | 21 | .82 | 45 | 1.68 | 229 | ..... | ..... |
| 4 | ..... | ..... | .63 | 31 | ..... | 280 | 22 | .82 | 45 | 2.25 | 490 | ..... | ..... |
| 5 | ..... | ..... | .60 | 29 | ..... | 500 | 23 | .75 | 39 | 2.22 | 472 | ..... | ..... |
| 6 | ..... | ..... | .57 | 27 | 2.15 | 430 | 24 | 1.14 | 96 | 2.19 | 454 | ..... | ..... |
| 7 | ..... | ..... | .50 | 23 | 2.10 | 400 | 25 | 1.58 | 200 | 2.22 | 472 | ..... | ..... |
| 8 | ..... | ..... | .46 | 21 | 1.80 | 270 | 26 | 1.20 | 109 | 1.99 | 341 | ..... | ..... |
| 9 | ..... | ..... | .38 | 16 | ..... | 600 | 27 | 1.06 | 81 | ..... | 280 | ..... | ..... |
| 10 | ..... | ..... | .38 | 16 | 3.50 | 1,240 | 28 | .83 | 46 | ..... | 240 | ..... | ..... |
| 11 | ..... | ..... | .38 | 16 | ..... | 550 | 29 | .70 | 35 | ..... | 210 | ..... | ..... |
| 12 | ..... | ..... | .37 | 16 | ..... | 350 | 30 | .66 | 33 | ..... | 360 | ..... | ..... |
| 13 | ..... | ..... | .39 | 17 | 1.80 | 270 | 31 | .72 | 37 | ..... | 190 | ..... | ..... |
| 14 | 1.09 | 86 | .40 | 17 | 2.23 | 478 | Mean | | 67.2 | ..... | 141 | ..... | 388 |
| 15 | 1.03 | 75 | .40 | 17 | ..... | 600 | Run-off per square mile | | .27 | ..... | .56 | ..... | 1.55 |
| 16 | .98 | 67 | .43 | 19 | ..... | 380 | | | | | | | |
| 17 | .90 | 54 | .50 | 23 | ..... | 270 | Run-off, depth in inches | | .18 | ..... | .65 | ..... | 1.15 |
| 18 | .94 | 60 | 1.03 | 75 | ..... | 200 | | | | | | | |

NOTE.—Discharges for days when gage was not read were estimated with the aid of a hydrograph.

### IRVING DITCH.

The Irving ditch was built in 1906, and has its intake on Kougarok River at the mouth of Washington Creek. It extends for 4½ miles along the north bank of the river to a point opposite the mouth of Columbia Creek, where a head of 160 feet is obtained.

The following measurements were made of the discharge of the ditch: August 12, 1.8 second-feet; September 9, 12.4 second-feet.

### HOMESTAKE DITCH.

The Homestake ditch of the Kugarok Mining and Ditch Company was begun in 1905 and completed in 1907. It diverts the water from the upper Kougarok, near Mascot Gulch, and extends along the left bank of the river to a point opposite the mouth of Homestake Creek, having a total length of 7½ miles. The water is carried across Macklin Creek in a siphon 843 feet long, of 36 and 34 inch pipe.

Above Macklin Creek the ditch is built into the rocky bluffs of close-grained schists and slates for about 1 mile. Below the siphon some ground ice was encountered, and also a large amount of loose rock mixed with ice and frozen muck, which gave much trouble. Nearly half of the length of the ditch had to be lined with sod, some parts requiring both sides and bottom of this material. (See Pl. VIII, *B*.) In 1907 a lateral ditch was built to Macklin Creek. It is 6,300 feet long and 4 feet wide on the bottom.

The water was used during the latter part of 1906 in the bed of the river just above Taylor Creek. A waste ditch was formed by a retaining wall built on one side of the channel, but at times this was overtopped and the workings flooded. The discharge at such times was estimated at 600 to 800 second-feet.

During the season of 1907 the water was used on the John L. bench claim, on the right bank of the river below Homestake Creek. A head of about 150 feet is available on this claim.

Two stations were maintained on the ditch, at the intake and just above the penstock. The discharge at the intake is given on page 81.

The station above the penstock was maintained during the high-water period of 1907, to determine the amount of water used at the mine. The gage was read by employees of the Kugarok Mining and Ditch Company.

*Discharge measurements of Homestake ditch above penstock, 1907.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| August 21 | 1.19 | 9.1 | August 26 | 1.60 | 18.0 |
| Do | 1.49 | 15.6 | September 11 | 1.74 | 21.0 |
| August 22 | 1.47 | 15.0 | | | |

*Daily gage height and discharge of Homestake ditch above penstock, 1907.*

| Day. | August. | | September. | | Day. | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.76 | 21.5 | 18 | | | 1.76 | 21.5 |
| 2 | | | 1.70 | 20.2 | 19 | | | 1.68 | 17.8 |
| 3 | | | 1.62 | 18.4 | 20 | | | 1.15 | 8.4 |
| 4 | | | 1.75 | 21.3 | 21 | 1.34 | 12.3 | | |
| 5 | | | 1.54 | 16.7 | 22 | 1.48 | 15.4 | | |
| 6 | | | 1.70 | 20.2 | 23 | 1.54 | 16.7 | | |
| 7 | | | 1.70 | 20.2 | 24 | 1.54 | 16.7 | | |
| 8 | | | 1.70 | 20.2 | 25 | 1.60 | 18.0 | | |
| 9 | | | 1.72 | 20.6 | 26 | 1.60 | 18.0 | | |
| 10 | | | 1.52 | 16.2 | 27 | 1.56 | 17.1 | | |
| 11 | | | 1.74 | 21.1 | 28 | 1.58 | 17.6 | | |
| 12 | | | 1.75 | 21.3 | 29 | 1.58 | 17.6 | | |
| 13 | | | 1.76 | 21.5 | 30 | 1.68 | 19.8 | | |
| 14 | | | 1.76 | 21.5 | 31 | 1.70 | 20.2 | | |
| 15 | | | 1.76 | 21.5 | | | | | |
| 16 | | | 1.74 | 21.1 | Mean | | 17.2 | | 19.6 |
| 17 | | | 1.76 | 21.5 | | | | | |

## TAYLOR CREEK AT NORTH STAR INTAKE.

Taylor Creek is the longest tributary of Kougarok River and is larger than the main stream at their junction. It rises near the headwaters of Noxapaga and Goodhope rivers and flows in a southwesterly direction. Its principal tributaries are Midnight, Solomon, Jim, Brown, Rock, and Arizona creeks. Two ditches have been

built on Taylor Creek—the North Star, with its intake about 3 miles above Solomon Creek, and the Cascade, which takes out water about 5 miles farther downstream.

The following measurements were made at North Star intake to determine the water supply available for the ditch: July 17, 12 second-feet; July 24, 174 second-feet; August 10, 3.8 second-feet; September 13, 94 second-feet. They indicate a discharge of 75 to 90 per cent of that at the Cascade intake; the drainage area is 58 square miles, or 78 per cent of that at the lower point.

### TAYLOR CREEK AT CASCADE INTAKE.

This station was established to determine the total water supply of the two ditches on Taylor Creek. It is located about 100 yards above the diversion dam of the ditch. During August and September a part of the discharge of the creek was diverted past the station in the North Star ditch; the amount of this diversion is given on page 87. The gage was read by employees of the Cascade Mining and Ditch Company.

*Discharge measurements of Taylor Creek at Cascade intake, 1907.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft* | | *Feet.* | *Sec.-ft.* |
| July 17 | 0.67 | 16 | August 10 | 0.49 | 4.6 |
| July 24 | 1.65 | 186 | August 21 | 1.95 | 268 |
| July 26 | .93 | 43 | August 24 | 1.30 | 91 |

*Daily gage height and discharge of Taylor Creek at Cascade intake, 1907.*

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* |
| 1 | | | | 7 | 1.12 | 67 | 18 | | 20 | 0.84 | 32 | 1.00 | 50 |
| 2 | | | | 7 | 1.24 | 87 | 19 | | 15 | 1.15 | 72 | | 45 |
| 3 | | | | 7 | 1.15 | 72 | 20 | | 13 | .95 | 44 | | 35 |
| 4 | | | | 6 | 1.25 | 89 | 21 | | 13 | 1.60 | 164 | | |
| 5 | | | | 6 | 1.55 | 152 | 22 | | 12 | 1.48 | 136 | | |
| 6 | | | | 6 | 1.36 | 110 | 23 | | 10 | 1.38 | 114 | | |
| 7 | | | | 5 | 1.25 | 89 | 24 | 1.65 | 186 | 1.25 | 89 | | |
| 8 | | | | 5 | 1.00 | 50 | 25 | | 80 | 1.65 | 178 | | |
| 9 | | | | 4.6 | 1.24 | 87 | 26 | .93 | 43 | | 147 | | |
| 10 | | | 0.49 | 4.6 | 2.40 | 430 | 27 | | 25 | 1.39 | 116 | | |
| 11 | | | | 4 | 1.80 | 220 | 28 | | 13 | | 98 | | |
| 12 | | | | 4 | 1.45 | 129 | 29 | | 8 | 1.20 | 80 | | |
| 13 | | | .31 | 2.5 | 1.30 | 98 | 30 | | 8 | 1.65 | 178 | | |
| 14 | | | .42 | 3.9 | 1.15 | 72 | 31 | | 8 | 1.20 | 80 | | |
| 15 | | 20 | .47 | 4.6 | 1.60 | 164 | | | | | | | |
| 16 | | 18 | .50 | 5.0 | 1.30 | 98 | Mean | | 29.9 | | 52.2 | | 111 |
| 17 | 0.67 | 16 | .57 | 9.2 | 1.15 | 72 | | | | | | | |

NOTE.—Discharges for days on which gage was not read were obtained by the aid of a hydrograph.

*Monthly discharge of Taylor Creek at Cascade intake, 1907.*

[Drainage area, 74 square miles.]

| Month. | Discharge in second-feet. | | | Run-off. | |
|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Sec.-ft. per sq. mile. | Depth in inches. |
| July 15-31 | 186 | 8 | 29.9 | 0.40 | 0.25 |
| August | 186 | 3.9 | 54.2 | .73 | .84 |
| September 1-20 | 441 | 35 | 119 | 1.61 | 1.20 |
| 68 days | 441 | 3.9 | 67.1 | .91 | 2.29 |

NOTE.—These values include the discharge of both the creek and North Star ditch; for daily discharge of the ditch see page 87.

### TAYLOR CREEK AT MOUTH.

The following measurements of Taylor Creek were made near the mouth, to compare its discharge with that of Kougarok River above the mouth of Taylor Creek and to determine the discharge available for a ditch at this level: July 17, 18 second-feet; July 26, 46 second-feet; July 29, 9.6 second-feet; August 10, 7.2 second-feet.

### NORTH STAR DITCH ABOVE SIPHON.

The North Star ditch of the Taylor Creek Ditch Company was begun in 1905 and completed in 1907. It diverts water from Taylor Creek about 12 miles above its mouth and about 3 miles above the mouth of Solomon Creek. The ditch lies on the left bank for the first mile, then crosses the creek in a flume and continues on the right bank to a point 7 miles below the intake. Here it crosses Taylor Creek in a siphon 2,600 feet long, composed of 40-inch steel pipe, riveted throughout, there being no slip joints. The pipe is carried across the creek on a suspension bridge about 100 feet long. The difference in elevation between the ends of the siphon is 19 feet, and the depression at the bottom 150 feet. Below the siphon the ditch receives the flow of Rock Creek and continues to Arctic Creek, having a total length of 15.2 miles.

Water was turned into the ditch at the intake about August 5, but was not run through the siphon until about the 20th. The water was used on the Thorson bench, on the left bank of Kougarok River, and for stripping on Dreamy Gulch, a small tributary from the east.

The station above the siphon was established to determine the amount of water diverted past the gage at the Cascade intake. The quantity used at the mines includes in addition the discharge of Rock Creek. The gage was read by employees of the Taylor Creek Ditch Company.

*Discharge measurements of North Star ditch above siphon, 1907.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| August 10 | | [a] 2.9 | September 5 | 1.14 | 7.0 |
| August 21 | 1.05 | 5.0 | September 13 | 1.24 | 9.7 |
| August 24 | .50 | 0.0 | Do | | [a] 8.0 |

[a] Measured at intake.

*Daily gage height and discharge of North Star ditch above siphon, 1907.*

| Day. | August. | | September. | | Day. | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.21 | 8.8 | 18 | | | 1.22 | 9.2 |
| 2 | | | 1.16 | 7.5 | 19 | | | | |
| 3 | | | 1.11 | 6.2 | 20 | | | | |
| 4 | | | 1.16 | 7.5 | 21 | | | | |
| 5 | | | 1.18 | 8.0 | 22 | 1.04 | 5.0 | | |
| 6 | | | 1.17 | 7.8 | 23 | 1.09 | 5.8 | | |
| 7 | | | 1.18 | 8.0 | 24 | | | | |
| 8 | | | 1.14 | 7.0 | 25 | 1.18 | 8.0 | | |
| 9 | | | 1.14 | 7.0 | 26 | 1.14 | 7.0 | | |
| 10 | | | 1.28 | 11.3 | 27 | 1.05 | 5.2 | | |
| 11 | | | 1.30 | 12.0 | 28 | 1.15 | 7.2 | | |
| 12 | | | 1.22 | 9.2 | 29 | 1.18 | 8.0 | | |
| 13 | | [a] 1.5 | 1.25 | 10.2 | 30 | 1.14 | 7.0 | | |
| 14 | | | 1.24 | 9.9 | 31 | 1.16 | 7.5 | | |
| 15 | | | 1.30 | 12.0 | | | | | |
| 16 | | | 1.28 | 11.3 | Mean | | [b] 6.2 | | 9.0 |
| 17 | | | 1.22 | 9.2 | | | | | |

[a] Estimated.

[b] Ten days.

## CASCADE DITCH.

The Cascade ditch was built in 1906. It diverts water from Taylor Creek about 7 miles above its mouth and 110 feet lower than the North Star ditch. For the first quarter of a mile the ditch lies on the left bank of the creek; it then crosses to the right bank in a flume about 60 feet long, and extends within a half a mile of the mouth of Taylor Creek, having a total length of 6¼ miles. The flow of the ditch was very irregular during 1907, on account of breaks, repairs, and interruption of work at the mine. The water was used to run a hydraulic elevator in the bed of Taylor Creek. The water supply of the ditch was insufficient for this purpose during the first two weeks of August, and the pit was flooded on account of insufficient waste-way capacity most of the time after August 20.

The following measurements were made of the discharge of the ditch:

*Discharge measurements of Cascade ditch, 1907.*

| Date. | Place. | Discharge. |
|---|---|---|
| | | *Sec.-ft.* |
| August 10 | Flume near intake | 4.4 |
| August 18 | Near penstock | 5.8 |
| August 21 | do | 4.5 |
| September 5 | do | 7.1 |

### HENRY CREEK.

Henry Creek, which enters Kougarok River about 2 miles below the mouth of Taylor Creek, is the largest tributary from the west, and in dry weather furnishes the steadiest high-level water supply in the Kougarok drainage area. Its headwaters lie south of the upper Kougarok River and adjoin those of Budd Creek on the west. Lincoln Creek, which rises between Henry and Coarse Gold creeks, is the most important tributary. Lillian Creek enters from the north, about 4 miles from the mouth.

The Henry Creek ditch, which was built by the T. T. Lane Company in 1905 and 1906, extends from Henry Creek about 2 miles above the mouth of Lincoln Creek to a point near the mouth of Homestake Creek, and has a total length of $10\frac{1}{4}$ miles. An additional $3\frac{1}{4}$ miles would divert Lincoln Creek. No water was running in the ditch in 1907. It is now the property of the Taylor Creek Ditch Company.

Measurements were made at the ditch intakes and also at the mouth. The total flow at ditch level on the dates when it was measured was about 70 per cent of that at the mouth, and has been estimated as the same proportion for days when measurements were made only at the mouth.

*Discharge measurements of Henry and Lincoln creeks, 1907.*

| Date. | Henry Creek at mouth. | At ditch level. | | |
|---|---|---|---|---|
| | | Henry Creek. | Lincoln Creek. | Total. |
| | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* | *Sec.-ft.* |
| July 16 | ..... | 10.0 | 8.2 | 18.2 |
| July 25 | 22.0 | 7.4 | 8.0 | 15.4 |
| July 30 | 9.6 | ..... | ..... | 6.8 |
| August 9 | 8.2 | ..... | ..... | 5.7 |
| August 13 | 6.8 | 2.7 | 2.3 | 5.0 |
| August 20 | 12.0 | 5.0 | 3.3 | 8.3 |
| August 23 | 60 | ..... | ..... | 42 |
| August 26 | 34 | ..... | ..... | 24 |
| August 29 | 27 | ..... | ..... | 19 |
| September 6 | 55 | ..... | ..... | 38 |
| September 12 | 99 | 41 | 42 | 83 |

The following measurements of Lillian Creek show the amount of water it would contribute to the Henry Creek ditch: July 16, 1.0 second-feet; August 20, 0.6 second-feet; September 12, 6 second-feet.

### COARSE GOLD CREEK.

Coarse Gold Creek is one of the larger tributaries of Kougarok River. It has a total length of about 16 miles, and flows in a northeasterly direction, entering the river about 25 miles above the mouth. The creek is relatively flat in its upper portion, and has a fall of 40 to 80 feet per mile in the lower 6 miles.

The Coarse Gold ditch, constructed in 1907, has its intake about 5 miles above the mouth, and is built along the south slope of the valley, picking up the flow of Jones Gulch and Nugget Gulch. It extends about 5 miles to Two-bit Gulch, a small tributary of Kougarok River, where a head of nearly 300 feet is obtained. Measurements were made near the mouth of the creek. They show the water supply available for the ditch, as practically the whole flow is diverted.

*Discharge measurements of Coarse Gold Creek near mouth, 1907.*

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Sec.-ft.* | | *Sec.-ft.* |
| July 21 | 7.8 | August 26 | 29 |
| July 30 | 3.5 | August 28 | 30 |
| August 8 | 3.4 | September 6 | 29 |
| August 12 | 3.0 | September 8 | 22 |
| August 23 | 44 | September 15 | 156 |

## NORTH FORK.

North Fork is formed by the junction of French and Alder creeks and enters Kougarok River from the east, about a mile below the mouth of Coarse Gold Creek. Its principal tributaries are Harris, Baldy, Monument, Queen, Magnet, and Eureka creeks. Harris Creek is dry during low water for the lower 4 miles, the water flowing underground through the limestone which forms its bed. The flow of North Fork also is underground for over a mile, and appears again as a spring about a mile above Harris Creek.

In 1906 the Northwestern Development Company began a ditch which has its intake just below the junction of French and Alder creeks, extends along the north bank about 3 miles, and then crosses in a siphon to the south bank. Six miles of ditch are completed.

A lower ditch is proposed which will take its water above Eureka Creek and will extend to Dahl Creek. Measurements were made to show the water available for both ditches.

*Discharge measurements of North Fork, 1907.*

| Date. | At Northwestern intake (drainage area, 20 square miles). | Above Eureka Creek (drainage area, 66 square miles). |
|---|---|---|
| | *Sec.-ft.* | *Sec.-ft.* |
| July 22 | 2.5 | 13.0 |
| August 15 | .7 | 9.6 |
| August 27 | 31 | 103 |
| September 7 | 17 | 70 |
| September 15 | [a]36 | 122 |

[a] Estimated.

## MISCELLANEOUS MEASUREMENTS.

Measurements of a number of the smaller streams and ditches in the Kougarok drainage are given in the following table. Their location is indicated on the map (Pl. VII, p. 78). Macklin Creek is tapped about 1 mile from the mouth by a branch of the Homestake ditch. The Okdurok ditch diverts the flow of Homestake Creek.

The Arizona Creek ditch is 2 miles long and is built to the benches of the Kougarok, having an elevation of 185 feet above the river. The Windy Creek ditch is 4 miles long and gives a head of 150 feet above the creek at Anderson Gulch, where the water is used for ground sluicing. The McMonagle, Dolan & McFadden, and Blocker & Sayle ditches divert water from Kougarok River between the Homestake intake and Macklin Creek, and are used to furnish a sluice head for shoveling into boxes.

*Miscellaneous measurements in Kougarok River drainage basin, 1907.*

CREEKS.

| Date. | Stream and locality. | Discharge. |
|---|---|---|
| | | *Sec.-feet.* |
| July 21 | Arctic, near mouth | 0.6 |
| August 26 | do | 1.5 |
| September 6 | do | 3.0 |
| August 29 | Arizona, including ditch | 5.1 |
| September 8 | do | 6.2 |
| August 29 | California, near mouth | 1.1 |
| July 12 | Coffee, near Wonder Gulch | .5 |
| July 27 | Columbia, near mouth | 1.5 |
| September 9 | do | 19 |
| September 7 | Eureka, near mouth | 5.8 |
| July 22 | Harris, claim 15 | 1.0 |
| August 22 | Homestake, including ditch | 4.0 |
| September 6 | do | 8.7 |
| August 19 | Macklin, including ditch | 5.5 |
| August 22 | do | 19 |
| September 11 | do | 20 |
| August 12 | Washington, near mouth | .13 |
| September 9 | do | 40 |
| July 13 | Windy, including ditch | 9.0 |
| July 31 | do | 4.8 |
| August 8 | do | 3.0 |

DITCHES.

| | | |
|---|---|---|
| August 29 | Arizona Creek ditch | 1.8 |
| September 8 | do | 1.8 |
| August 19 | Blocker & Sayle ditch | 3.0 |
| September 11 | do | 4.1 |
| August 19 | Dolan & McFadden ditch | 2.5 |
| Do | Macklin branch | 4.0 |
| Do | McMonagle ditch | 3.0 |
| August 22 | Okdurok ditch | 3.0 |
| September 6 | do | 2.3 |
| July 31 | Windy Creek ditch | 1.8 |
| August 8 | do | 1.0 |

## TOTAL WATER SUPPLY IN 1907.

The amount of water that would have been available in 1907 for the use of the principal ditches of the Kougarok drainage basin,

built and proposed, is summarized by weekly periods in the accompanying table. The following points should be noted:

The flow available "for Dahl Creek at elevation 300 to 350 feet" is the quantity that could have been diverted by proposed low-line ditches, one taking water from Kougarok River near Dreamy Gulch and from Henry Creek near the mouth, the other from North Fork above Eureka Creek. These ditches could be combined into one below the mouth of North Fork. The water in the North Star and Henry Creek ditches could be carried past the intakes and used below them, so that the flow available for the low-line ditch as given in the table would be reduced by the amount so diverted. Practically none of the discharge of Coarse Gold Creek would be available for this ditch, as it would be used in the high-level ditch.

The flow available for "upper Kougarok at elevation 600 to 700 feet" is the sum of the discharges of the five principal forks of the river at the ditch intakes. At least 75 per cent of the discharge of Taylor Creek is available for the North Star ditch and the remainder for the Cascade ditch. The values for Henry and Coarse Gold creeks and North Fork were estimated with the aid of hydrographs and are only approximate.

Several other streams would furnish some water at high and low level, notably Homestake and Rock creeks. At low water this would be less than 1 second-foot for any single stream and may be disregarded; at high water it would not be needed.

*Mean weekly water supply, in second-feet, of Kougarok River drainage basin, 1907.*

| Date. | For Dahl Creek at elevation 300 to 350 feet. | | | For upper Kougarok at elevation 600 to 700 feet. | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Kougarok River. | North Fork. | Total. | Kougarok River. | Taylor Creek. | Henry Creek. | Coarse Gold Creek. | North Fork. | Total. |
| July 15–21 | 57 | 22 | 79 | 14 | 16 | 19 | 12 | 5.2 | 66 |
| July 22–28 | 88 | 22 | 110 | 13 | 53 | 14 | 9.6 | 3.0 | 93 |
| July 29–August 4 | 33 | 12 | 45 | 6.7 | 7.3 | 7.3 | 3.8 | 1.2 | 26 |
| August 5–11 | 21 | 10 | 31 | 5.4 | 5.0 | 6.3 | 3.3 | 1.0 | 21 |
| August 12–18 | 26 | 13 | 39 | 4.5 | 9.0 | 5.4 | 3.9 | 1.0 | 24 |
| August 19–25 | 328 | 73 | 401 | 60 | 117 | 28 | 29 | 30 | 264 |
| August 26–September 1 | 262 | 83 | 345 | 33 | 117 | 21 | 26 | 27 | 224 |
| September 2–8 | 331 | 76 | 407 | 57 | 100 | 33 | 27 | 21 | 238 |
| September 9–15 | 584 | 117 | 701 | 133 | 181 | 94 | 100 | 44 | 552 |
| September 16–20 | 228 | 45 | 273 | 46 | 68 | 33 | 39 | 17 | 203 |
| Mean | 196 | 47 | 243 | 37.3 | 67.3 | 26.1 | 25.4 | 15.0 | 171 |
| Maximum | 584 | 117 | 701 | 133 | 181 | 94 | 100 | 44 | 552 |
| Minimum | 21 | 10 | 31 | 4.5 | 5.0 | 5.4 | 3.3 | 1.0 | 21 |

## NOXAPAGA RIVER DRAINAGE BASIN.

Noxapaga River is the largest tributary of the Kuzitrin, and enters that stream from the north about 15 miles above the mouth of the Kougarok. The northwestern portion of its basin resembles that of Kougarok River, which it adjoins. An extensive lava flow

covers the eastern portion, and the southern or lower end lies in the lowland area known as the Kuzitrin Flats.

Above the mouth of Goose Creek the river has been crossed by a recent lava flow, forming rapids in which there is a descent of 96 feet in 2.3 miles. Above the rapids the river has hardly any fall for several miles.

During 1907 a ditch was built by the McKay Hydraulic Mining Company from Turner Creek, a tributary to the Noxapaga from the northwest, to benches on the river above Goose Creek. It has a total length of 16 miles, and diverts water from Turner, Boulder, Miller, Winona, and several smaller creeks.

Measurements were made in this drainage basin at extreme low water and in no wise represent the average flow. The seasonal variation of the smaller streams was probably as great as in the Kougarok River basin, and the high-water discharge of the Noxapaga can probably be safely estimated as the same per square mile as that of the Kougarok.

*Discharge measurements in Noxapaga River drainage basin, 1907.*

| Date. | Stream and locality. | Drainage area | Discharge. |
|---|---|---|---|
| | | *Sq. miles.* | *Sec.-feet.* |
| August 15 | Turner Creek at McKay intake | 13 | 0.7 |
| Do | Boulder Creek at claim 5 | | .8 |
| August 16 | Noxapaga River above Goose Creek | 340 | 62 |

## SERPENTINE RIVER DRAINAGE BASIN.

Serpentine River drains a large area lying north of the Kougarok. Measurements were made of only a few streams in the headwaters.

### SCHLITZ AND REINDEER CREEKS.

These creeks rise on the slope of Midnight Mountain, and flow northwestward into Serpentine River. A ditch has been started by the Kugarok Mining and Ditch Company which will be about 8 miles long and will divert the flow of these creeks over a low divide into Macklin Creek, where it will be picked up by a branch of the Homestake ditch. Measurements were made near the proposed diversions, as follows: Schlitz Creek, August 11, 0.7 second-feet; September 4, 13 second-feet. Reindeer Creek, August 11, 1.9 second-feet; September 3, 13 second-feet.

### BRYAN AND DICK CREEKS.

Bryan Creek rises to the east of Kougarok Mountain and flows northeastward into Serpentine River. Dick Creek is its principal tributary and has shown the best values of all the streams in this

drainage basin. A ditch built by the Pittsburg-Dick Creek Mining Company in 1906 and 1907 diverts the water of Bryan Creek and extends along the left or north bank of the creek for 6½ miles to the mouth of Dick Creek, where a head of about 170 feet is available. The following measurements were made of Bryan Creek near the intake: July 19, 4.2 second-feet; July 27, 6.0 second-feet; July 28, 6.5 second-feet; September 2, 15.5 second-feet.

### QUARTZ AND BISMARCK CREEKS.

Quartz Creek is the name applied to the headwaters of South Fork of Serpentine River. It rises west of Kougarok Mountain and flows in a northerly direction. Bismarck Creek is a small tributary of Quartz Creek. In 1907 the Pittsburg-Dick Creek Mining Company began a ditch which will take water from these creeks and carry it over the divide to a small tributary of Bryan Creek, where it will be picked up by the Bryan Creek ditch. The Quartz Creek ditch is about 350 feet higher than the Bryan Creek ditch and is about 8 miles long. Plans are made to extend it to upper Dick Creek, giving it a total length of 22 miles. Measurements were made about 200 feet lower than the intakes, and not over 75 per cent of the discharge at these points would be available for the ditch.

The gage on Quartz Creek was read during the low water of August by S. G. Revelas.

The following measurements were made of Bismarck Creek: July 19, 1.7 second-feet; July 28, 2.0 second feet.

*Gage heights and discharges of Quartz Creek, 1907.*

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| MEASUREMENTS. | | | GAGE READINGS—cont'd. | | |
| | *Feet.* | *Sec.-feet.* | | *Feet.* | *Sec.-feet.* |
| July 19 | | 8.2 | August 5 | 0.60 | 9.0 |
| July 28 | 0.60 | 9.0 | August 7 | .61 | 9.6 |
| September 2 | .80 | 25.0 | August 9 | .62 | 10.2 |
| | | | August 11 | .60 | 9.0 |
| GAGE READINGS. | | | August 13 | .62 | 10.2 |
| | | | August 15 | .62 | 10.2 |
| August 1 | .61 | 9.6 | August 17 | .64 | 11.4 |
| August 3 | .60 | 9.0 | August 19 | .64 | 11.4 |

## AMERICAN RIVER DRAINAGE BASIN.

American River, the north fork of the Agiapuk, drains a large area west of the Kougarok basin. Measurements were made only on Budd Creek, the tributary on which the most extensive development work has been done.

Budd Creek rises northwest of Kougarok Mountain and flows southeastward to the mouth of Eldorado Creek, thence southwestward to American River above the forks. The waters of Budd and

Eldorado creeks sink into the limestone which forms their beds, and after flowing from 2 to 4 miles underground appear as springs. Windy Creek is a large tributary from the south, on which some mining has been done.

In 1907 a ditch was built on the north bank of Budd Creek by the Ottumwa Gold Mining Company. It takes its water just below the spring and extends to a point below the mouth of Windy Creek, a distance of 8 miles. A head of about 160 feet is obtained. A second ditch was built by the same company on Million and Ohio creeks, tributaries of Windy Creek.

The following measurements were made August 31, when the water was at about as low a stage as it reached during the season, the rains beginning later here than in the Kougarok basin: Budd Creek Spring, drainage area 58 square miles; discharge, 25 second-feet. Budd Creek below Windy Creek, drainage area, 108 square miles; discharge, 39 second-feet.

## HYDRAULIC DEVELOPMENT.

The first discovery of gold on any tributary of Kougarok River was made on Harris Creek in 1900. The river and creek claims were nearly all staked during the following summer, and values were found at many points. The district has continued as a producer since that time, but the total output of precious metal has been small compared with that of other districts in Seward Peninsula. In the lower part of the Kougarok region Dahl Creek has been the largest producer. Work on this stream is greatly handicapped by the scarcity of water. Dahl Creek has a small area and lies in a region of small run-off, so that it is only during the melting of the snow in the spring and for a few days after a heavy rain that enough water for sluicing can be obtained from the creek.

During 1903 and 1904 the first ditch in the region was built by the T. T. Lane Company. It extends from Coffee to Dahl Creek, diverting Carrie and Independence creeks along its course. In 1904 capital began to turn its attention to the upper Kougarok. Three large ditches were begun late that year or early in 1905—the Homestake, North Star, and Henry Creek ditches. In 1906, the Cascade, Irving, and North Fork ditches were built, and work was continued on the other three. In 1907 only one ditch, that on Coarse Gold Creek, was built in the Kougarok basin. Several developments were carried out on streams in adjacent drainage areas, including the McKay ditch from Turner Creek to Noxapaga River, the Bryan and Quartz creek ditches, and the Ottumwa ditch on Budd Creek. Most of these ditches have been described in the foregoing pages. The following tables summarize their principal features. The capacities are approximate in most cases.

*Ditches in Kougarok region, Seward Peninsula.*

| Name. | Diverts from— | Extends to— | Date completed. | Length. | Bottom width. | Fall per mile. | Capacity. | Pressure obtained. |
|---|---|---|---|---|---|---|---|---|
| | | | | *Miles.* | *Feet.* | *Feet.* | *Sec.-ft.* | *Feet.* |
| Kugarok Mining and Ditch Co.: | | | | | | | | |
| Homestake | Kougarok River | Homestake Creek. | 1907 | 7.5 | 8 | 3.17–4.22 | 25 | 160 |
| Macklin Branch | Macklin Creek | Main ditch | 1907 | 1.2 | 4 | 4.22 | 5 | ..... |
| Arctic | Reindeer and Schlitz creeks. | Macklin divide | (*a*) | 8 | 5 | 4.22 | 10 | ..... |
| Irving Mining Co. | Kougarok River | Columbia Creek | 1907 | 4.4 | 6 | 4.22 | 15 | 160 |
| Taylor Creek Ditch Co.: | | | | | | | | |
| North Star | Taylor Creek | Arctic Creek | 1907 | *b* 7 | 8 | 3.70 | 40 | ..... |
| | | | 1907 | *c* 8 | 10 | 4.22 | 40 | 200 |
| Cascade Mining and Ditch Co. | do | Claim 3 | 1907 | 6.25 | 5.5 | 4.22 | 12 | 110 |
| T. T. Lane Co.: | | | | | | | | |
| Henry Creek | Henry Creek | Homestake Creek. | (*d*) | 10.25 | 6 | 3.17 | 15 | 210 |
| | Lincoln Creek | Henry Creek intake. | (*d*) | 3.25 | ..... | ..... | ..... | ..... |
| Coffee Creek | Coffee Creek | Dahl Creek | 1904 | 12.25 | 3–5 | 3.17 | ..... | ..... |
| C. F. Merritt and others. | Arizona Creek | Benches on river | 1905 | 2 | 4 | 3.17 | 2 | 185 |
| Galvin & Buell | Coarse Gold Creek. | Two-bit Gulch | 1907 | 5 | 8 | 4.22 | 25 | 300 |
| Northwestern Development Co. | North Fork | ..... | (*a*) | 6 | 7 | 3.17 | 20 | ..... |
| Anderson Bros. | Windy Creek | Anderson Gulch | 1906 | 4 | 4 | 4.22 | 8 | 150 |
| McKay Hydraulic Mining Co. | Turner Creek | Goose Creek | 1907 | 16 | 4–5 | 4.22 | 8–10 | ..... |
| Pittsburg-Dick Creek Mining Co. | Bryan Creek | Dick Creek | 1907 | 6.5 | 6 | 4.22 | 15 | 170 |
| | Quartz Creek | Bryan Creek divide. | (*a*) | 8 | 8 | 4.22 | 20 | *e* 350 |
| Ottumwa Gold Mining Co. | Budd Creek | Below Windy Creek. | 1907 | 8 | 9 | 3.70 | 30 | 160 |
| | Million Creek | Windy Creek | 1907 | ..... | 4 | 4.22 | 8 | ..... |

*a* Under construction.
*b* Intake to siphon.
*c* Siphon to Arctic Creek.
*d* Proposed.
*e* Above Bryan Creek ditch.

## RELATIVE RUN-OFF OF DIFFERENT AREAS.

In order to afford a comparison of the run-off conditions in different areas, especially between those north and south of the Kigluaik Mountains, tables have been prepared showing the daily minima and monthly means for 1906 and 1907 in second-feet per square mile for the drainage areas investigated. The streams have been grouped into three classes—(1) those running in the foothills, having southern exposures and but few gulches in which snow is retained into the summer months; (2) streams rising in the mountains, having deep valleys and cirques with northern exposures, where snow is stored and held during the whole summer, and having a much heavier rainfall than streams at lower elevations; (3) streams of the Kougarok region. A study of the following tables shows several interesting points. In general, the nearer the stream lies to the central mountain mass of the Kigluaik Range, the greater is its run-off. The most notable exception to this rule is Hobson Creek. The flow of this stream comes from limestone springs, which are believed to draw some of their water from areas lying outside the surface

drainage basin of the creek. North Star Creek, Fox Creek, and Nome River have a smaller minimum than adjoining streams whose basins have a similar character and elevation. This is probably due to their more direct southern exposure.

There is a striking difference, both in minimum and mean, between streams south of the mountains and those in the Kougarok region. This is due mostly to the small rainfall north of the mountains. Budd Creek draws all of its flow at low water from springs and so has a much larger minimum than other streams in the vicinity.

These tables may be used to estimate the run-off from other streams in Seward Peninsula, but such estimates must be made with extreme caution on account of the great difference in run-off in areas apparently similar.

The streams are not given in the order in which the descriptions appear in the text, but are arranged in general from east to west and from higher elevations to lower.

*Minimum daily flow of streams in Seward Peninsula, 1906–7.*

STREAMS RISING IN FOOTHILLS.

| Stream. | Elevation. | Drainage area. | 1906. | | | 1907. | | |
|---|---|---|---|---|---|---|---|---|
| | | | Date. | Minimum flow. | Minimum run-off per square mile. | Date. | Minimum flow. | Minimum run-off per square mile. |
| | *Feet.* | *Sq. miles.* | | *Sec.-ft.* | *Sec.-ft.* | | *Sec.-ft.* | *Sec.-ft.* |
| Iron Creek below mouth of Canyon Creek. | 450 | 50 | Aug. 14..... | 17.1 | 0.34 | Aug. 11–14.. | 33 | 0.66 |
| Eldorado River below mouth of Venetia Creek. | 400 | 51 | Aug. 14..... | 44 | .86 | ..... | ..... | ..... |
| Jett Creek..... | 800 | 1.4 | Sept. 10..... | [a] 4.2 | 3 | Sept. 23..... | 2.9 | 1.3 |
| Copper Creek..... | 800 | .85 | Aug. 11..... | .8 | .94 | ..... | ..... | ..... |
| Nugget Creek..... | 785 | 2.1 | June 28..... | [b] .96 | .46 | Aug. 10–11.. | 2.8 | 1.3 |
| David Creek..... | 590 | 4.3 | Aug. 19..... | 3.3 | .77 | Sept. 30..... | 8.3 | 1.9 |
| Dorothy Creek..... | 500 | 2.7 | Aug. 18..... | 2.9 | 1.1 | ..... | ..... | ..... |
| Hobson Creek..... | 500 | 2.6 | July 4..... | 10.5 | [c] 4 | Aug. 19..... | 14.3 | 5.5 |
| Slate Creek (tributary to Stewart River). | 700 | 2.1 | Aug. 19..... | 2.2 | 1.05 | ..... | ..... | ..... |
| Stewart River..... | 400 | 36 | Aug. 19..... | 11.4 | .32 | ..... | ..... | ..... |
| Snake River..... | 40 | 69 | ..... | ..... | ..... | Aug. 12..... | 77 | 1.1 |
| Penny River..... | 120 | 19 | Aug. 1..... | [a] 36 | 1.9 | Aug. 15..... | 33 | 1.7 |

[a] Lowest measurements obtained; the flow was less on certain dates.
[b] The lowest flow later in 1906 was 3 second-feet, or 1.4 second-feet per square mile, on August 11.
[c] The flow of Hobson Creek is from large limestone springs whose catchment area may not coincide with the surface watershed.

*Minimum daily flow of streams in Seward Peninsula, 1906–7*—Continued.

STREAMS RISING IN KIGLUAIK MOUNTAINS.

| Stream. | Elevation. | Drainage area. | 1906. | | | 1907. | | |
|---|---|---|---|---|---|---|---|---|
| | | | Date. | Minimum flow. | Minimum run-off per square mile. | Date. | Minimum flow. | Minimum run-off per square mile. |
| | *Feet.* | *Sq. miles.* | | *Sec. ft.* | *Sec. ft.* | | *Sec. ft.* | *Sec. ft.* |
| North Fork Grand Central River near ditch intake. | 750 | 5.4 | July 1..... | 23 | 4.3 | ..... | ..... | ..... |
| West Fork Grand Central River at ditch intake. | 850 | 5.4 | Sept. 15–17.. | 19 | 3.5 | July 29..... | 28 | 5.2 |
| Crater Lake outlet.. | 925 | 1.8 | Sept. 15–17.. | 3.1 | 1.7 | Sept. 22–23.. | 3.5 | 1.9 |
| Thompson Creek.... | 720 | 2.5 | Sept. 16–17.. | 5 | 2 | Sept. 22–23.. | 5 | 2 |
| Grand Central River below forks. | 690 | 14.6 | Sept. 16–17.. | 47 | 3.1 | Aug. 15..... | 72 | 4.9 |
| Grand Central River below Nugget Creek. | 455 | 39 | Sept. 16–17.. | 90 | 2.3 | ..... | ..... | ..... |
| Grand Central River between station below forks and station at Nugget Creek. | ..... | 24.4 | Sept. 16–17.. | 43 | 1.76 | ..... | ..... | ..... |
| Kruzgamepa River.. | 442 | 81 | {Aug. 19 and Sept. 17.} | 175 | 2.16 | Oct. 5..... | 178 | 2.2 |
| Crater Creek..... | 550 | 11 | Sept. 16–17.. | 39 | 3.5 | ..... | ..... | ..... |
| Fox Creek..... | 550 | 11 | Aug. 16..... | 17.3 | 1.6 | ..... | ..... | ..... |
| Nome River..... | 575 | 15 | Aug. 5..... | 20 | 1.3 | Aug. 15..... | 16 | 1.1 |
| Buffalo Creek..... | 800 | 4.4 | Aug. 3..... | 9.1 | 2.1 | ..... | ..... | ..... |
| Sinuk River..... | 770 | [b] 6.2 | Aug. 3..... | 20 | 3.2 | Aug. 15..... | [a] 22 | 2.7 |
| North Star Creek.... | 900 | 2.3 | Aug. 10..... | 2.9 | 1.26 | Aug. 7..... | [a] 4 | 1.7 |
| Windy Creek..... | 650 | 12 | Aug. 3..... | 32 | 2.7 | Aug. 15..... | [a] 32 | 2.7 |

[a] Minimum in midseason. [b] 8.2 after August 1, 1907.

STREAMS IN THE KOUGAROK REGION.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kougarok River at Homestake intake. | ..... | 44 | ..... | ..... | ..... | Aug. 13..... | 3.2 | 0.07 |
| Kougarok River above Coarse Gold Creek. | ..... | 250 | ..... | ..... | ..... | Aug. 9–12... | 16 | .06 |
| Taylor Creek at Cascade intake. | ..... | 74 | ..... | ..... | ..... | Aug. 14..... | 3.9 | .05 |
| Henry Creek at mouth. | ..... | 50 | ..... | ..... | ..... | Aug. 13..... | 6.8 | .14 |
| North Fork above Eureka Creek. | ..... | 66 | ..... | ..... | ..... | Aug. 15..... | 9.6 | .15 |
| Noxapaga River.... | ..... | 340 | ..... | ..... | ..... | Aug. 16..... | 62 | .18 |
| Turner Creek..... | ..... | 13 | ..... | ..... | ..... | Aug. 15..... | .7 | .05 |
| Budd Creek..... | ..... | 58 | ..... | ..... | ..... | Aug. 21..... | 25 | .43 |

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*Mean run-off, in second-feet per square mile, at gaging stations, 1906.*

| Station. | Drainage area. | July 1–31. | July 1–4 and 11–31. | Aug. 1–31. | Sept. 1–30. | Sept. 1–18. |
|---|---|---|---|---|---|---|
| | *Sq. mi.* | | | | | |
| North Fork of Grand Central River: | | | | | | |
| Near ditch intake | 5.4 | ..... | [a] 7.53 | 6.80 | ..... | 5.85 |
| At pipe intake | 2.3 | ..... | ..... | 11.9 | ..... | 9.65 |
| West Fork of Grand Central River: | | | | | | |
| At ditch intake | 5.4 | ..... | 10.3 | 6.02 | ..... | 4.72 |
| At pipe intake | 2.8 | ..... | 9.64 | 4.96 | ..... | 3.36 |
| Crater Lake outlet | 1.8 | ..... | 10.8 | 6.56 | ..... | 2.89 |
| Thompson Creek | 2.5 | ..... | 8.20 | 6.64 | ..... | 3.04 |
| Grand Central River below forks | 14.6 | ..... | 8.36 | 5.84 | ..... | 4.25 |
| Grand Central River below Nugget Creek | 39 | ..... | ..... | [a] 4.42 | ..... | 3.36 |
| Kruzgamepa River at outlet of Salmon Lake | 81 | 7.05 | ..... | 3.20 | 5.63 | 3.05 |
| Between Grand Central River below the forks and Kruzgamepa River stations. | 66 | ..... | ..... | 2.62 | ..... | 2.79 |
| Nome River at Miocene intake | 15 | 3.43 | 2.71 | 3.36 | 4.29 | ..... |

[a] Approximate.

*Mean run-off, in second-feet per square mile, at gaging stations, 1907.*

STREAMS RISING IN FOOTHILLS.

| Station. | Drainage area. | July 1–31. | July 8–31. | August. | Sept. 1–30. | Sept. 1–23. |
|---|---|---|---|---|---|---|
| | *Sq. miles.* | | | | | |
| Jett and Copper creeks | 2.25 | 7.69 | ..... | 3.16 | 4.27 | ..... |
| Nugget Creek | 2.1 | 2.71 | ..... | 2.95 | 5.24 | ..... |
| David Creek | 4.3 | 7.49 | ..... | 3.30 | 4.81 | ..... |
| Hobson Creek | 2.6 | 8.69 | ..... | 6.58 | 7.35 | ..... |
| Snake River | 69 | 2.56 | ..... | 1.56 | ..... | ..... |
| Penny River | 19 | 4.14 | ..... | 3.11 | 3.74 | ..... |

STREAMS RISING IN KIGLUAIK MOUNTAINS.

| | | | | | | |
|---|---|---|---|---|---|---|
| North Fork Grand Central River: | | | | | | |
| At the forks | 6.9 | ..... | 7.06 | 8.42 | ..... | 9.38 |
| At pipe intake | 2.3 | ..... | 16.9 | 18.9 | ..... | 20.2 |
| West Fork Grand Central River: | | | | | | |
| At the forks | 7.7 | ..... | 11.0 | 10.5 | ..... | 13.0 |
| At ditch intake | 5.4 | ..... | 11.1 | 9.30 | ..... | 9.38 |
| At pipe intake | 2.8 | ..... | 9.43 | 6.29 | ..... | 7.32 |
| Crater Lake outlet | 1.8 | ..... | 13.6 | 14.4 | ..... | 11.7 |
| Thompson Creek | 2.5 | ..... | 16.9 | 10.8 | ..... | 9.12 |
| Kruzgamepa River at outlet Salmon Lake | 81 | 6.77 | ..... | 4.14 | 5.89 | ..... |
| Nome River at Miocene intake | 15 | 4.81 | ..... | 2.19 | 3.89 | ..... |
| Sinuk River | [a] 6.2 | 8.44 | ..... | 5.49 | ..... | 6.55 |
| North Star Creek | 2.3 | 6.43 | ..... | 3.61 | ..... | 3.87 |
| Windy Creek | 12 | 7.62 | ..... | 4.93 | ..... | 5.68 |

[a] 8.2 after August 1.

STREAMS IN THE KOUGAROK REGION.

| Station. | Drainage area. | July 15–31. | August. | Sept. 1–20. |
|---|---|---|---|---|
| | *Sq. miles.* | | | |
| Kougarok River: | | | | |
| At Homestake intake | 44 | 0.28 | 0.52 | 1.80 |
| Above Coarse Gold Creek | 250 | .27 | .56 | 1.55 |
| Taylor Creek at Cascade intake | 74 | .40 | .73 | 1.61 |

# THE FAIRHAVEN PRECINCT.

By Fred F. Henshaw.

## INTRODUCTION.

The Fairhaven precinct, comprising a large area in northeastern Seward Peninsula, has been a producer of placer gold since 1901 and promises to be more important in the future. No stream-gaging work has been done in this district, and it has not been visited by any member of the Geological Survey since 1903. The following notes concerning the water supply and the hydraulic developments that have been carried on during the last two seasons have been compiled from reliable sources.

## FAIRHAVEN DITCH.

The Fairhaven ditch was built during 1906 by the Fairhaven Water Company. It takes its water supply from Imuruk Lake, the source of Kugruk River. A dam about 500 feet long has been constructed across the outlet of the lake to conserve the run-off.

The upper section of the ditch is 17 miles long, the first 8 miles of which is through a lava formation. The water is dropped into upper Pinnell River, and flows down this stream for about 4 miles. The lower section takes the water from Pinnell River on its right bank and extends for 23 miles to Arizona Creek, where a head of 500 feet is obtained. The ditch is 11 feet wide on the bottom and has a grade of 5 feet to the mile.

The dam across Imuruk Lake was closed August 16, 1906, and remained so until August, 1907, no water being carried in the ditch in the meantime. The water surface of the lake rose 26 inches during this period. The area of the lake is 30 square miles and that of the drainage basin 99 square miles. The run-off was therefore 41,600 acre-feet, equivalent to 7.9 inches in depth over the entire drainage area. This would furnish 58 second-feet for one year, 210 second-feet for one hundred days, or 263 second-feet for eighty days. The snowfall during the winter of 1906–7 was heavier than usual, so that the water supply for other years may be less than this.

The above information was furnished by W. R. Hoffman, who had charge of the construction of the Fairhaven ditch.

### CANDLE DITCH.

The Candle ditch was built during 1907 by the Candle-Alaska Hydraulic Gold Mining Company to furnish water for mining on Candle Creek. It has a total length of 33.6 miles, a bottom width of 9 feet, and a grade of 3.69 feet per mile. The estimated capacity is 35 second-feet. It takes its supply from the western tributaries of Kiwalik River. The present intake of the ditch is on Glacier Creek. The water is carried across Dome Creek in a siphon 2,250 feet long, composed of 28-inch pipe; across Bonanza Creek in 900 feet of 32-inch pipe; and across Eldorado Creek in a siphon 12,100 feet long, composed of equal lengths of 35½, 37½, and 39½ inch pipe. Eldorado Creek will be tapped with a lateral ditch about 6 miles long. An extension 8.1 miles long of 6-foot ditch will be built to Gold Run. It will also be possible to divert the flow from the headwaters of First Chance Creek, a tributary of Koyuk River, over a low divide into Gold Run.

The fall obtained is 250 feet at the mouth of Candle Creek and 132 feet at the mouth of Patterson Creek. The surveyed line crosses Candle Creek about 1 mile above the mouth of Willow Creek. Candle Creek was nearly dry during 1907, the flow some of the time being less than half a second-foot.

The above information was furnished by W. L. Leland.

### BEAR CREEK DITCH.

A ditch was built in 1907 on Bear Creek, a tributary of the West Fork of Buckland River. It has its intake below the mouth of May Creek, and extends along the right bank to Split Creek, diverting Eagle, Polar, and other small creeks. The ditch has a length of about 6 miles, a bottom width of 6 feet, and a grade of 4 feet to the mile. The head obtained at the lower end is about 200 feet.

# THE FAIRBANKS DISTRICT.

By C. C. Covert.

## DESCRIPTION OF AREA.

The area known as the Fairbanks district extends about 60 miles to the north of Fairbanks and is from 40 to 50 miles in width. The greater part of the region lies in the lower Tanana basin, but a portion to the northwest is directly tributary to the Yukon. Generally speaking, it embraces three divisions—a low, broad alluvial plain, a moderately high plateau, and a mountain mass.

The low, broad plain forms the bottom lands of the lower Tanana Valley, which in this section is divided into several parts by the Tanana and its slough-like channels. The main slough starts near the mouth of Salcha River, about 30 miles above Fairbanks, where it diverts a portion of the Tanana waters. Its course is along the foothills of the plateau to the north, and it receives Chena River about 7 miles above Fairbanks. The plain is swampy in character and is well covered with timber along the banks of the streams. In the vicinity of Fairbanks it has a general elevation of about 500 feet above sea level.

The plateau is drained by streams tributary to Tanana River, which flow through rather broad, unsymmetrical valleys, most of which extend in a northeast-southwest direction. Their bottom lands range in elevation from 500 to over 2,000 feet above sea level, and the dividing ridges are in general 2,000 to 3,000 feet above the stream beds. That portion of the plateau which comes under discussion in this report is drained principally by Little Chena and Chatanika rivers. The upper region of these drainage basins is crosscut by a zigzag range, which separates the Yukon from the Tanana drainage.

The mountain mass to the north of this plateau forms what might be termed the apex of the divide between the Tanana and the Yukon drainage basins. It rises to an altitude of 4,000 to 5,000 feet above sea level and its corrugated slopes are drained principally by tributaries to Yukon River.

All drainage areas tributary to the Tanana are similar in character. The streams have little slope except near their source. Wide, gravelly beds of a shifting nature and tortuous courses keeping to one

side of the valley are marked characteristics. The channels usually have rather steep banks that form approaches to broad, level bottom lands which extend from 1,000 to 4,000 feet or more before they meet the abrupt slopes of the dividing ridges. The drainage basins are from 4 to 15 miles wide and are well cut up by small tributary streams flowing through deep and narrow ravines.

A large portion of the area is covered with a thick turf known as tundra, which is wet, spongy, and mossy and ranges in thickness from 6 inches to 2 feet. In some localities this is meadow like, producing a rank growth of grass and a variety of beautiful wild flowers. Underneath this tundra ground ice is found in many places, particularly on the northern slopes, where the soil is scanty and there is little timber or other vegetation. The soil of the southern slopes is, for the most part, gravelly clay, underlain by a mica schist which affords suitable ground for ditch construction. When stripped of its mossy covering, the sun rapidly thaws it so that the plow and scraper can be used to advantage.

Above an altitude of 2,000 to 2,200 feet practically the only vegetation is a scrubby, bushy growth which attains a height of 2 to 4 feet. In general the country below this altitude is timbered by spruce and birch, with scattered patches of tamarack and willow along the banks of the smaller streams. The timber increases in density and size as the river bottoms are approached. There the prevailing growth is spruce, much of which attains diameters of 18 to 24 inches.

The Fairbanks mining district lies between Little Chena and Chatanika rivers. It embraces an area of some 500 square miles and extends about 30 miles to the north of Fairbanks, which is situated on Chena Slough nearly 12 miles above its confluence with the Tanana. The producing creeks in general rise in a high rocky ridge, of which Pedro Dome, with an elevation of about 2,500 feet, is the center. At least half of the mines are located at an elevation of over 800 feet, and 25 per cent over 1,000 feet, above sea level.

The field work during 1907 in the Fairbanks district was carried on from June 20 to September 15. Owing to the lack of adequate funds the work was largely that of reconnaissance. However, the keeping of systematic records on some of the more important streams was made possible through the hearty cooperation of people who were interested.

After making a careful study of the general topographic conditions of the mining district and surrounding country, it was decided to establish a few regular stations, at the most convenient points in the larger drainage areas, and study the daily run-off, during the open

season from records thus obtained.[a] This plan afforded greater opportunity for procuring comparative data than that of covering a larger territory in a less definite way. In this country without storage, daily records are an important factor, and such records could not have been obtained over an extended area. Outside of the producing creeks the country is practically a wilderness, and it is almost impossible to get observations, other than those made on the occasional visits of the engineer. No daily or even weekly records in such areas could have been assured and the results obtained from the occasional measurements would have furnished no comprehensive idea as to the actual daily run-off of the streams throughout the open season.

## CONDITIONS AFFECTING WATER SUPPLY.

Stream flow in the Fairbanks district is affected by melting of accumulated snow and ice, summer rains, and melting of ground ice. In this district the break-up begins about the middle of April and the rise in the streams commences about the middle of May and continues intermittently until May 30, or thereabouts, when the maximum discharge occurs. The table on page 109 shows the daily gage height of Chena Slough at Fairbanks during the open season of 1907. A. D. Gassaway, of the Chatanika Ditch Company, estimated the maximum flow of Chatanika River near the mouth of Faith Creek at about 1,250 second-feet and stated that this discharge occurred about May 30. After that date the flow gradually decreased until the minimum stage was reached, about July 10.

The precipitation records kept at Fairbanks since 1905 (see table p. 143) show that snowfall in this section amounts to about 40 inches. On account of the frozen ground and the steady cold weather, very little of this snow runs off before the spring break-up. What run-off there is during the winter season, especially in the upper basins, is accumulated in the glacial ice formed in the stream beds. This ice does not entirely disappear before the middle or last of July.

There are few data regarding rainfall in this section. Records have been kept at Fairbanks since 1905 and in connection with the investigations of stream flow the Geological Survey established four stations in 1907. The daily and monthly rainfall at these points is given in the tables on pages 140 to 141. A comparison of the 1907 rainfall records throughout Alaska, especially those of the interior, with records previously obtained will show that the season was a comparatively normal one.

[a] For explanation of data and methods of work see p. 9.

The melting of frozen ground affords a slight additional supply of water to the streams. The frozen muck and ground ice, which carry a large percentage of water, are well protected by a thick coat of moss, through which it is difficult for the heat of the summer sun to penetrate. As the season advances the imprisoned moisture is liberated through the combined influence of abundant sunshine and frequent warm rains. This gradual thawing of frozen ground is made noticeable not only by the increase of the daily flow of the streams, but also by the condition of the trail and the increased depth to which one sinks when traveling over the tundra. On the northern slope and in the deep canyons, which are protected from the rays of the sun, the frozen ground never thaws more than a few inches, even during July and August, when the sun shines nearly twenty-four hours a day.

Owing to the shallow depth to which the ground thaws, the prevailing mossy covering affords the only ground storage for rainfall in this country. This covering is filled with seepage from ground thaw and consequently any increase in the water supply, through rainfall, finds its way to the streams in a very short time over the underground ice and steep slopes of the drainage basins, causing streams to rise and fall very rapidly. (See fig. 2.) Because of this lack of ground storage the streams depend largely on rainfall for their supply, after the snow and ice have disappeared in the spring break-up. May, June, and July are invariably months of slight rainfall in the interior (see p. 140) and the streams soon reach a very low stage. Yet this is the most important period for the miner. The long hours of daylight and the warm weather afford favorable opportunities for mining and sluicing, but the abundant supply of water needed for this purpose is often lacking.

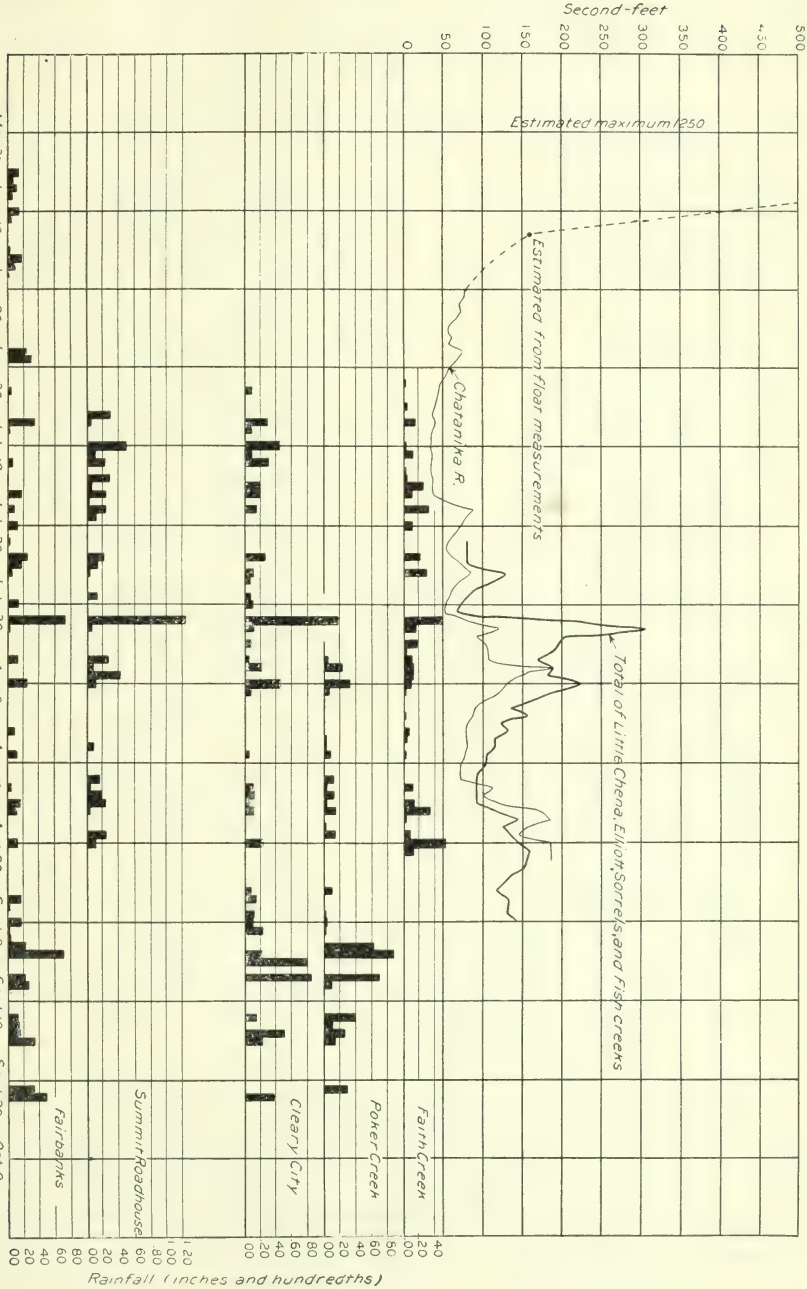



FIG. 2.—Diagram showing flow of Chatanika River and total flow of Little Chena River and its tributaries in 1907.

### GAGING STATIONS.

The following list gives the points in the Fairbanks district at which gages were established or discharge measurements made in 1907. The numbers refer to Pl. IX:

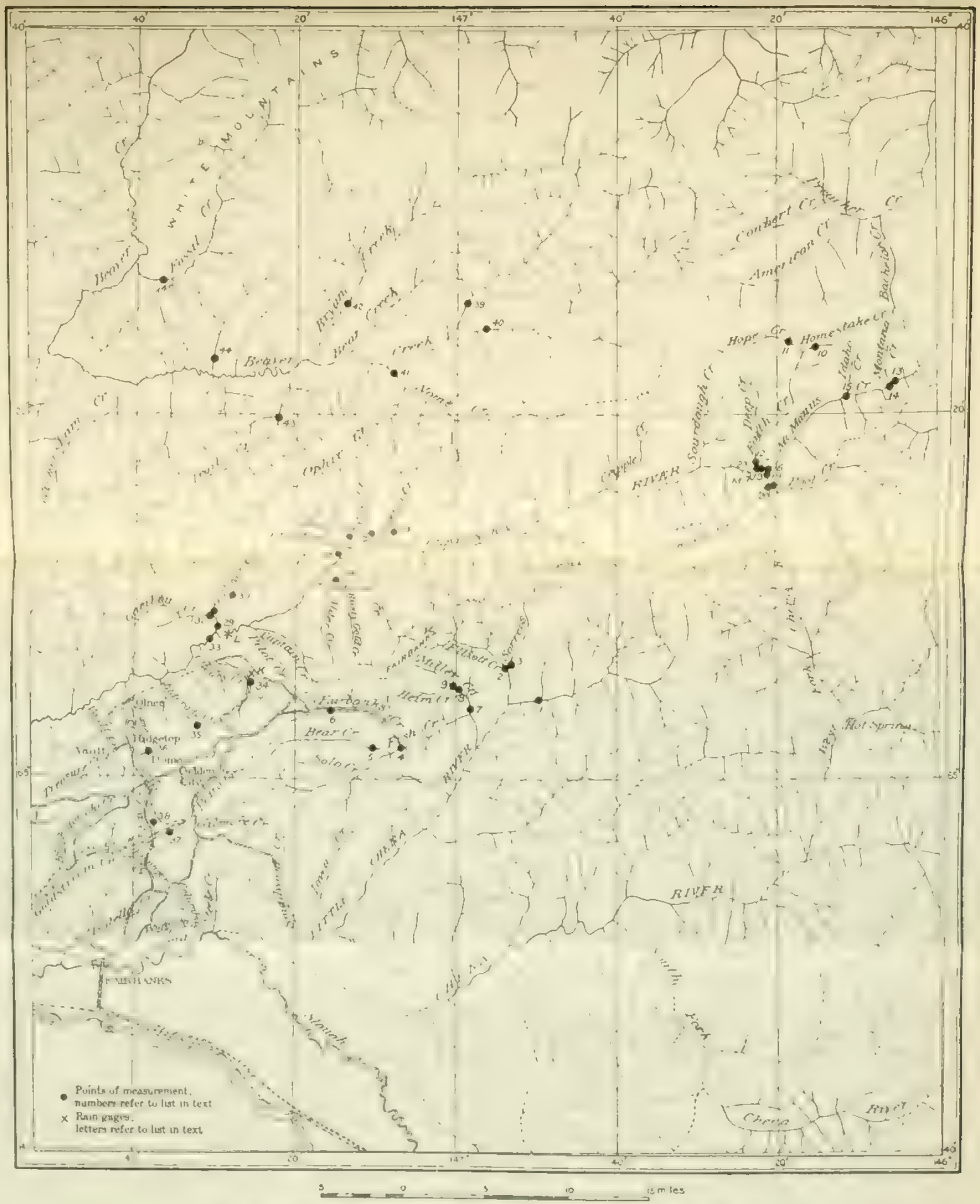
*Gaging stations in Fairbanks district.*

1. Little Chena River about 2 miles above Elliott Creek.
2. Elliott Creek above mouth of Sorrels Creek.
3. Sorrels Creek above mouth.
4. Fish Creek above Fairbanks Creek.
5. Bear Creek near mouth of Tecumseh Creek.
6. Fairbanks Creek.
7. Miller Creek near mouth.
8. Miller Creek below Heim Creek.
9. Miller Creek above Heim Creek.
10. Charity Creek 1 mile above mouth of Hope Creek.
11. Hope Creek near mouth of Zephyr Creek.
12. Faith Creek at weir near mouth.
13. McManus Creek above Montana Creek.
14. McManus Creek below Montana Creek.
15. McManus Creek 1 mile below Idaho.
16. McManus Creek 500 feet above mouth of Smith Creek.
17. McManus Creek below mouth of Smith Creek.
18. McManus Creek at mouth.
19. Smith Creek below mouth of Pool Creek.
20. Smith Creek above mouth of Pool Creek.
21. Pool Creek above mouth.
22. McManus Creek at weir near mouth.
23. Chatanika River below Faith and McManus creeks.
24. Boston Creek, elevation 800 feet.
25. McKay Creek, elevation 800 feet.
26. Belle Creek, elevation 800 feet.
27. Crooked Creek near mouth.
28. Kokomo Creek near mouth.
29. Poker Creek near mouth.
30. Poker Creek near elevation 800 feet.
31. Little Poker Creek above mouth.
32. Caribou Creek above mouth of Little Poker Creek.
33. Chatanika River below mouth of Poker Creek.
34. Cleary Creek near Cleary.
35. Little Eldorado Creek above trail to Dome.
36. Dome Creek near Dome.
37. Goldstream Creek at claim 6 below.
38. Fox Creek near elevation 900 feet.
39. Beaver Creek above mouth of East Branch.
40. East Branch Beaver Creek above mouth.
41. Nome Creek 1 mile above mouth.
42. Bryan Creek, elevation 1,800 feet.
43. Trail Creek about 4 miles above mouth.
44. Brigham Creek 1 mile above mouth.
45. Fossil Creek near mouth.

## LITTLE CHENA RIVER DRAINAGE BASIN.

### GENERAL DESCRIPTION.

The southern slope of the divide between the Chatanika and Chena drainage basins, from the headwaters of Smith and Flat creeks to Pedro Dome, a distance of about 25 miles, is drained by Little Chena River and its tributaries, Elliott and Fish creeks. The drainage basin is irregular in shape and has a network of small, ramifying streams with steep, precipitous slopes in their upper drainage. The upper portion of the main stream is also steep, having a fall of 100 to 150




MAP SHOWING LOCATION OF GAGING STATIONS IN FAIRBANKS REGION

feet to the mile. This slope decreases rather abruptly to about 18 feet to the mile in the vicinity of Elliott and Fish creeks.

The general course of the stream above the confluence of Fish Creek is through a rather broad, unsymmetrical valley. Below Fish Creek the river takes the center of a deep, narrow channel for about 8 miles to the point where Anaconda Creek, an important tributary from the left, enters. Below this point the valley gradually widens until the stream enters the lowlands tributary to Chena River, into which it empties 6 or 8 miles above the confluence of Chena Slough. Through this slough it discharges its waters into the Tanana near the town of Chena.

In the low-water period the stream has a channel width of 30 to 75 feet and flows from side to side of a broad, gravelly bed ranging from 100 to 300 feet in width. The channel is defined by steep, alluvial banks forming the approach to the heavily timbered bottom lands of the river valley which prevail above the confluence of Fish Creek. In the high-water stages the broad river bed is filled to its banks and often overflows them. During this stage the river seeks numerous smaller channels that surround heavily wooded islands.

The greater part of the drainage basin is well covered with timber, that in the uplands, on the slopes and smaller divides, consisting of spruce, birch, and poplar, suitable only for fuel and cabin purposes. In the lower valleys and creek bottom lands the prevailing growth is spruce, much of which is suitable for milling purposes.

The area is invariably covered with the conventional moss, but here and there outcroppings of limestone, mica schist, and gravel are found on the slopes. In the creek valleys the mossy covering is usually underlain with frozen muck and glacial ice. Numerous swamp areas occur near the river banks, and these, together with the heavy growth of timber, make travel very difficult.

Gaging stations were established on Fish Creek above the mouth of Fairbanks Creek, on Elliott Creek above the mouth of Sorrels Creek, on Sorrels Creek above its mouth, and on the Little Chena about 2 miles above the mouth of Elliott Creek. Much credit is due Sherman White, the observer, for his faithful work in making approximately daily observations at each of these stations.

A project is under way to collect the waters from the different tributaries, at an elevation of about 900 feet, and to convey the supply by ditch line to a point in the lower drainage area, on the right bank of the Little Chena, where a fall of nearly 200 feet can be obtained. A portion of the water so collected is to be used in developing electric power for transmission to the producing creeks, and the excess water will be carried by ditch line to Smallwood and Nugget creeks and used for mining purposes.

The following table gives the horsepower (80 per cent efficiency) per foot of fall that may be developed at different rates of discharge, and shows the number of days on which the discharge and the corresponding horsepower were respectively less than the amounts given in the columns for "discharge" and "horsepower."

*Discharge and horsepower table for Little Chena River and tributaries, 1907.*

| Discharge.[a] | Horsepower (80 per cent efficiency) per foot fall. | Days of deficient discharge, July 22 to Sept. 10. | Discharge.[a] | Horsepower (80 per cent efficiency) per foot fall. | Days of deficient discharge, July 22 to Sept. 10. |
|---|---|---|---|---|---|
| *Sec.-ft.* | | | *Sec.-ft.* | | |
| 66 | 6 | 0 | 154 | 14 | 35 |
| 88 | 8 | 7 | 176 | 16 | 42 |
| 110 | 10 | 15 | 198 | 18 | 45 |
| 132 | 12 | 23 | 220 | 20 | 48 |

[a] This includes the flow of Little Chena, Elliott, Sorrels, and Fish creeks.

*Drainage areas of Little Chena River basin.*[a]

| Stream and location. | Area. | Total area. |
|---|---|---|
| | *Sq. miles.* | *Sq. miles.* |
| Little Chena River above gaging station | 79.0 | 79.0 |
| Little Chena River from gaging station to mouth of Elliott Creek | 3.6 | 82.6 |
| Elliott Creek above gaging station | 13.8 | |
| Sorrels Creek above gaging station | 21.0 | |
| Elliott Creek from gaging station to mouth | 3.8 | |
| Total Elliott Creek | 38.6 | 121.2 |
| Little Chena River from mouth of Elliott to Fish Creek | 6.0 | 127.2 |
| Fish Creek above Bear Creek | 23.6 | |
| Bear Creek above mouth | 12.0 | |
| Fish Creek from Bear Creek to gaging station | 3.6 | |
| Fish Creek above gaging station | 39.2 | |
| Fairbanks Creek above mouth | 20.5 | |
| Fish Creek, Fairbanks Creek to Miller Creek | 13.0 | |
| Miller Creek above mouth | 16.5 | |
| Fish Creek from Miller Creek to mouth | 1.0 | |
| Total Fish Creek | 90.2 | 217.4 |
| Little Chena from mouth of Fish Creek to Anaconda Creek | 30.7 | 248.1 |
| Anaconda Creek above mouth | 43.3 | 291.4 |
| Little Chena from Anaconda Creek to mouth | 113.2 | 404.6 |

[a] From reconnaissance map Yukon-Tanana region, Fairbanks quadrangle.

## CHENA SLOUGH AT FAIRBANKS.

Near the mouth of Salcha River a portion of the Tanana waters are diverted through a sloughlike channel about 50 miles in length, that separates the broad flat lands to the right into two parts. The channel receives the drainage of the plateau to the north and about midway in its course Chena River enters. Below this point the channel is known as Chena Slough. It affords a passageway for the Tanana steamers from its mouth near Chena to Fairbanks, 12 miles above, except in times of low water, when the cargoes are transferred at Chena to the Tanana Mines Railroad.

A gage fastened to the highway bridge in Fairbanks is read twice each day during the open season by employees of the Northern Navigation Company.

*Daily gage height, in feet, of Chena Slough near Fairbanks, Alaska, 1907.*

| Day. | May. | June. | July. | Aug. | Sept. | Day. | May. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 5.3 | 2.4 | 3.2 | 1.9 | 17 | | 3.6 | 3.0 | 3.4 | 6.1 |
| 2 | | 5.2 | 2.6 | 3.4 | 1.8 | 18 | | 3.8 | 2.9 | 3.3 | 6.0 |
| 3 | | 5.1 | 2.8 | 3.9 | 1.6 | 19 | | 3.1 | 2.7 | 3.1 | 4.8 |
| 4 | | 4.6 | 2.8 | 3.8 | 1.5 | 20 | | 2.6 | 2.5 | 3.1 | 4.0 |
| 5 | | 4.0 | 2.6 | 3.8 | 1.4 | 21 | | 2.1 | 2.8 | 3.1 | 3.8 |
| 6 | | 4.8 | 2.1 | 3.9 | 1.4 | 22 | | 2.0 | 3.1 | 3.3 | 3.9 |
| 7 | | 5.6 | 2.2 | 4.0 | 1.4 | 23 | | 2.8 | 3.4 | 3.1 | 4.0 |
| 8 | | 4.8 | 2.3 | 4.0 | 1.4 | 24 | 5.6 | 1.5 | 3.5 | 3.0 | ..... |
| 9 | | 4.4 | 2.2 | 4.1 | 1.5 | 25 | 5.8 | 1.4 | 3.6 | 2.5 | ..... |
| 10 | | 4.0 | 2.0 | 4.1 | 1.8 | 26 | 5.6 | 1.5 | 3.6 | 2.2 | ..... |
| 11 | | 3.9 | 2.1 | 4.1 | 2.0 | 27 | 5.2 | 1.2 | 3.3 | 2.1 | ..... |
| 12 | | *4.1 | 2.1 | 3.9 | 2.0 | 28 | 4.6 | 1.3 | 3.1 | 2.0 | ..... |
| 13 | | 4.1 | 2.3 | 3.6 | 3.3 | 29 | 4.1 | 1.5 | 3.0 | 1.8 | ..... |
| 14 | | 3.9 | 2.6 | 3.6 | 5.3 | 30 | 5.5 | 2.0 | 3.0 | 1.8 | ..... |
| 15 | | 3.8 | 2.9 | 3.6 | 4.6 | 31 | 5.9 | ..... | 3.0 | 1.8 | ..... |
| 16 | | 3.5 | 3.1 | 3.5 | 4.3 | | | | | | |

## LITTLE CHENA RIVER ABOVE MOUTH OF ELLIOTT CREEK.

A gaging station was established on Little Chena River about 2 miles above the mouth of Elliott Creek July 22, 1907. At this point the channel is from 30 to 50 feet in width during low and medium stages. It has a gravelly bed and is fairly straight for about 100 feet. A stake graduated to feet and tenths was driven near the left side and daily readings were taken.

*Discharge measurements of Little Chena River above mouth of Elliott Creek, 1907.*

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sq.-ft.* | *Feet.* | *Sec.-ft.* |
| July 22 | 23.5 | 26.6 | 0.60 | 44.2 |
| July 24 | 23.5 | 26.7 | .565 | 39.7 |
| August 4 | 40.0 | 42.2 | 1.10 | 113 |
| August 5 | 33 | 37.2 | 1.05 | 103 |
| August 20 | 25 | 28.0 | .73 | 56.7 |

*Daily gage height and discharge of Little Chena River above mouth of Elliott Creek, 1907.*

[Elevation, 800 feet; drainage area, 79 square miles.]

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | 0.7 | 53 | 1.0 | 95 | 20 | ..... | ..... | .7 | 53 | ..... | ..... |
| 2 | ..... | ..... | 1.3 | 157 | .9 | 80 | 21 | ..... | ..... | .7 | 53 | ..... | ..... |
| 3 | ..... | ..... | 1.1 | 113 | .9 | 80 | 22 | 0.60 | 42 | .7 | 53 | ..... | ..... |
| 4 | ..... | ..... | 1.1 | 113 | .8 | 66 | 23 | ..... | 42 | .7 | 53 | ..... | ..... |
| 5 | ..... | ..... | 1.1 | 113 | .9 | 80 | 24 | .60 | 42 | .7 | 53 | ..... | ..... |
| 6 | ..... | ..... | 1.0 | 95 | .95 | 88 | 25 | .60 | 42 | ..... | 73 | ..... | ..... |
| 7 | ..... | ..... | 1.05 | 104 | .95 | 88 | 26 | .90 | 80 | 1.0 | 95 | ..... | ..... |
| 8 | ..... | ..... | 1.1 | 113 | 1.0 | 95 | 27 | .80 | 66 | .9 | 80 | ..... | ..... |
| 9 | ..... | ..... | 1.2 | 134 | ..... | 95 | 28 | .70 | 53 | .9 | 80 | ..... | ..... |
| 10 | ..... | ..... | 1.1 | 113 | 1.0 | 95 | 29 | .60 | 42 | ..... | 88 | ..... | ..... |
| 11 | ..... | ..... | 1.0 | 95 | ..... | ..... | 30 | .60 | 42 | 1.0 | 95 | ..... | ..... |
| 12 | ..... | ..... | .9 | 80 | ..... | ..... | 31 | .60 | 42 | 1.0 | 95 | ..... | ..... |
| 13 | ..... | ..... | 1.0 | 95 | ..... | ..... | | | | | | | |
| 14 | ..... | ..... | .8 | 66 | ..... | ..... | Mean | | [a]49.3 | ..... | 85.4 | ..... | [b]86.2 |
| 15 | ..... | ..... | .9 | 80 | ..... | ..... | Run-off per square mile | | .625 | ..... | 1.68 | ..... | 1.09 |
| 16 | ..... | ..... | .8 | 66 | ..... | ..... | Run-off, depth in inches | | .23 | ..... | 1.24 | ..... | .40 |
| 17 | ..... | ..... | ..... | 66 | ..... | ..... | | | | | | | |
| 18 | ..... | ..... | ..... | 60 | ..... | ..... | | | | | | | |
| 19 | ..... | ..... | ..... | 60 | ..... | ..... | | | | | | | |

[a] July 22–31.

[b] September 1 to 16.

### ELLIOTT CREEK ABOVE MOUTH OF SORRELS CREEK.

Elliott Creek takes the drainage from the southern slope of Twin Butte Hills, in the Chatanika divide, and flows in a southerly direction, discharging its waters and those of Sorrels Creek, its tributary, into the Little Chena about 4 miles above the mouth of Fish Creek.

The drainage area is steep in its upper reaches and well timbered in the creek bottom. The stream flows in a narrow channel, rather deeply cut, and the banks are lined with willow and small spruce.

A gaging station was established about half a mile above the mouth of Sorrels Creek July 22, 1907, and regular readings were taken.

*Discharge measurements of Elliott Creek above mouth of Sorrels Creek, 1907.*

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| July 23 | 9.5 | 6.4 | 1.6 | 5.1 |
| August 5 | 12.0 | 9.6 | 1.85 | 13.8 |
| August 20 | 10.1 | 6.98 | 1.615 | 7.1 |

*Daily gage height and discharge of Elliott Creek above mouth of Sorrels Creek, 1907.*

[Elevation, 800 feet; drainage area, 13.8 square miles.]

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.7 | 9.0 | 1.8 | 12.3 | 20 | | | 1.6 | 5.8 | | |
| 2 | | | 2.1 | 23 | 1.8 | 12.3 | 21 | | | 1.6 | 5.8 | | |
| 3 | | | 2.1 | 23 | 1.7 | 9.0 | 22 | 1.6 | 5.8 | 1.6 | 5.8 | | |
| 4 | | | | 17.2 | 1.7 | 9.0 | 23 | 1.6 | 5.8 | 1.6 | 5.8 | | |
| 5 | | | 1.8 | 12.3 | 1.7 | 9.0 | 24 | 1.6 | 5.8 | 1.6 | 5.8 | | |
| 6 | | | 1.8 | 12.3 | | 9.0 | 25 | 1.6 | 5.8 | | 7.4 | | |
| 7 | | | | 12.3 | | 9.0 | 26 | 1.7 | 9.0 | 1.7 | 9.0 | | |
| 8 | | | 1.8 | 12.3 | 1.7 | 9.0 | 27 | 1.7 | 9.0 | 1.7 | 9.0 | | |
| 9 | | | 1.9 | 15.6 | | 10.0 | 28 | 1.6 | 5.8 | 1.8 | 12.3 | | |
| 10 | | | 1.8 | 12.3 | | 12.0 | 29 | 1.6 | 5.8 | | 12.3 | | |
| 11 | | | 1.8 | 12.3 | | | 30 | | 4.1 | | 12.3 | | |
| 12 | | | 1.7 | 9.0 | | | 31 | 1.5 | 2.5 | 1.8 | 12.3 | | |
| 13 | | | 1.8 | 12.3 | | | | | | | | | |
| 14 | | | 1.8 | 12.3 | | | Mean | [a] 5.9 | | | 11.0 | | [b] 10.0 |
| 15 | | | 1.7 | 9.0 | | | Run-off per square mile | 0.43 | | | 0.797 | | 0.724 |
| 16 | | | 1.7 | 9.0 | | | Run-off, depth in inches | .16 | | | .92 | | .27 |
| 17 | | | | 9.0 | | | | | | | | | |
| 18 | | | | 7.4 | | | | | | | | | |
| 19 | | | 16.5 | 7.4 | | | | | | | | | |

[a] July 22 to 31.

[b] September 1 to 10.

### SORRELS CREEK.

Sorrels Creek, a tributary to Elliott Creek about 3 miles above its mouth, rises in the Chatanika divide, to the west of Flat Creek, and flows westward along this divide for about 5 miles, then, by an abrupt bend to the left, it takes a southerly course for about 6 miles to

Elliott Creek. The stream flows in a narrow irregular channel, rather deeply cut in the mucklike bottom lands, and is well hidden from view by the masses of spruce and willow along its banks.

A gaging station was established on this stream about one-half mile above its mouth July 23, 1907, and regular readings were taken.

*Discharge measurements of Sorrels Creek near mouth, 1907.*

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| July 23 | 11.0 | 9.95 | 1.00 | 10.3 |
| August 5 | 17.0 | 16.8 | 1.40 | 28.2 |
| August 20 | 12.0 | 10.7 | 1.02 | 12.0 |

*Daily gage height and discharge of Sorrels Creek near mouth, 1907.*

[Elevation, 800 feet; drainage area, 21 square miles.]

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.1 | 14.7 | 1.2 | 19.0 | 20 | | | 1.0 | 10.3 | | |
| 2 | | | 1.4 | 27.8 | 1.2 | 19.0 | 21 | | | 1.0 | 10.3 | | |
| 3 | | | 1.4 | 27.8 | 1.1 | 14.7 | 22 | 1.0 | 10.3 | 1.0 | 10.3 | | |
| 4 | | | 1.5 | 32.1 | 1.1 | 14.7 | 23 | 1.0 | 10.3 | 1.0 | 10.3 | | |
| 5 | | | 1.35 | 25.6 | 1.1 | 14.7 | 24 | 1.0 | 10.3 | 1.0 | 10.3 | | |
| 6 | | | 1.3 | 23.4 | | 14.7 | 25 | 1.0 | 10.3 | | 12.5 | | |
| 7 | | | | 23.4 | | 14.7 | 26 | 1.1 | 14.7 | 1.1 | 14.7 | | |
| 8 | | | 1.3 | 23.4 | 1.1 | 14.7 | 27 | 1.1 | 14.7 | 1.1 | 14.7 | | |
| 9 | | | 1.4 | 27.8 | | 14.7 | 28 | 1.0 | 10.3 | 1.2 | 19.0 | | |
| 10 | | | 1.3 | 23.4 | | 19.0 | 29 | 1.0 | 10.3 | | 19.0 | | |
| 11 | | | 1.3 | 23.4 | | | 30 | | 8.2 | | 19.0 | | |
| 12 | | | 1.2 | 19.0 | | | 31 | .9 | 6.0 | 1.2 | 19.0 | | |
| 13 | | | 1.2 | 19.0 | | | | | | | | | |
| 14 | | | 1.2 | 19.0 | | | Mean | [a]10.5 | | 18.2 | | [b]16 | |
| 15 | | | 1.1 | 14.7 | | | Run-off per square mile | 0.500 | | 0.867 | | .762 | |
| 16 | | | 1.1 | 14.7 | | | Run-off depth in inches | .19 | | 1.00 | | .28 | |
| 17 | | | | 14.7 | | | | | | | | | |
| 18 | | | | 12.5 | | | | | | | | | |
| 19 | | | | 10.3 | | | | | | | | | |

[a] July 22–31.

[b] Sept. 1–10.

## FISH CREEK ABOVE MOUTH OF FAIRBANKS CREEK.

Fish Creek rises in the high ridge at the head of Goldstream Creek and flows in a northeasterly direction through an irregularly formed valley. About 14 miles below its source it makes an abrupt bend to the right, flowing around the point of a rather steep divide that separates its drainage from that of the Little Chena, into which it discharges about 2 miles below this bend. Its principal tributaries are Solo, Bear, Fairbanks, and Miller creeks, all from the left. These streams are rather steep in their upper courses but rapidly lessen in slope as Fish Creek Valley is approached. Fish Creek has a tortuous course and closely follows the right side of the valley, having a rather broad, marshy bottom land on the left.

A gaging station was established a short distance above Fairbanks Creek July 22, 1907 (see Pls. IX; XI, *B*), and regular readings were taken.

*Discharge measurements of Fish Creek above mouth of Fairbanks Creek, 1907.*

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| July 21 | 9.5 | 10.4 | 1.00 | 23.7 |
| July 25 | 10.0 | 12.2 | 1.00 | 24.3 |
| August 3 | 14.5 | 17.5 | 1.55 | 47.8 |
| August 4 | 12.7 | 14.0 | 1.35 | 37.6 |
| August 19 | 9.2 | 9.95 | 1.00 | 20.8 |

*Daily gage height and discharge of Fish Creek above mouth of Fairbanks Creek, 1907.*

[Elevation, 925 feet; drainage area, 39 square miles.]

| Day. | July. | | August. | | September. | | Day. | July. | | August. | | September. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 3.2 | 155 | 1.0 | 24 | 20 | | | | 24 | | |
| 2 | | | 2.4 | 100 | 1.0 | 24 | 21 | | | 1.0 | 24 | | |
| 3 | | | 1.4 | 39 | 1.0 | 24 | 22 | 1.0 | 24 | 1.0 | 24 | | |
| 4 | | | 1.3 | 35 | 1.0 | 24 | 23 | | 24 | | 24 | | |
| 5 | | | | 37 | 1.1 | 27 | 24 | | 24 | 1.0 | 24 | | |
| 6 | | | 1.4 | 39 | | 27 | 25 | 1.0 | 24 | 1.1 | 27 | | |
| 7 | | | 1.55 | 47 | | 27 | 26 | 1.1 | 27 | 1.1 | 27 | | |
| 8 | | | 1.3 | 35 | 1.1 | 27 | 27 | 1.0 | 24 | 1.0 | 24 | | |
| 9 | | | 1.6 | 50 | 1.1 | 27 | 28 | .9 | 21 | 1.0 | 24 | | |
| 10 | | | 1.6 | 50 | 1.3 | 35 | 29 | .9 | 21 | | 27 | | |
| 11 | | | | 39 | | | 30 | .8 | 18 | 1.2 | 31 | | |
| 12 | | | 1.2 | 31 | | | 31 | .8 | 18 | 1.1 | 27 | | |
| 13 | | | 1.1 | 27 | | | | | | | | | |
| 14 | | | 1.1 | 27 | 2.6 | [a] 115 | Mean | [b] 22.5 | | 36.8 | | [c] 26.6 | |
| 15 | | | 1.1 | 27 | | | Run-off per square mile | .577 | | .944 | | .682 | |
| 16 | | | 1.0 | 24 | | | Run-off, depth in inches | .21 | | 1.09 | | .25 | |
| 17 | | | 1.0 | 24 | | | | | | | | | |
| 18 | | | | 24 | | | | | | | | | |
| 19 | | | 1.0 | 24 | | | | | | | | | |

[a] Not included in mean. [b] July 22 to 31. [c] Sept. 1 to 10.

## BEAR CREEK.

Bear Creek rises in the high divide at the head of Goldstream Creek, flows eastward through a deep, narrow valley, and empties into Fish Creek about one-half mile above the gaging station. Measurements were made on this creek below the mouth of Tecumseh Creek as follows: July 20, 8.4 second-feet; August 22, 7 second-feet; drainage area, 12 square miles; run-off per square mile, 0.70 and 0.584 second-foot, respectively.

## FAIRBANKS CREEK.

Fairbanks Creek rises on the eastern side of Pedro Dome, opposite the headwaters of Cleary Creek, and flows in an easterly direction for about 10 miles to Fish Creek. It is separated from Bear Creek on the

right by a steep, high ridge, rising from 800 to 1,000 feet above the stream bed. The valley to the left has a more gradual slope and is drained by several small tributaries—Moose, Crane, Alder, Walnut, and Deep creeks. The stream has rather steep slopes in its upper course. Below Moose Creek the average fall is about 75 feet to the mile. The stream flows close to the dividing ridge on the east until it approaches the broad lowland near Fish Creek. The lower portion flows through a narrow, deep-cut channel, thickly lined with willow and spruce.

Discovery claim is located near Alder Creek. Mining operations are carried on from claim 9 above to claim 13 below. The pay streak follows closely to the stream channel down to claim 9 below, where it swings to the left limit. Above claim 2 below most of the work is by the open-cut method. Below this point it is underground by drifting. The following measurements were made in 1907, but owing to the unfavorable conditions they are approximate only:

*Discharge measurements of Fairbanks Creek, 1907.*

| Date. | Elevation. | Discharge. |
|---|---|---|
| | *Feet.* | *Sec.-ft.* |
| June 24 | 1,300 | 1.4 |
| Do | 1,250 | 2.2 |
| July 5 | 1,375 | .72 |
| July 20 | 1,400 | 1.3 |

## MILLER CREEK.

Miller Creek rises in the southeasterly slope of Coffee Dome, and flows in a southerly direction, emptying into Fish Creek about 2 miles above its confluence with Little Chena River. It is about 6 miles long and flows through a narrow valley, draining an area of 16.7 square miles. The following discharge measurements were made in 1907:

*Discharge measurements of Miller Creek, 1907.*

| Date. | Point of measurement. | Elevation. | Drainage area. | Discharge. | Run-off per square mile. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. miles.* | *Sec.-ft.* | *Sec.-ft.* |
| July 6 | Near mouth | 750 | 15 | 7.0 | 0.47 |
| July 24 | do | 750 | 15 | 7.6 | .51 |
| August 20 | do | 750 | 15 | 8.0 | .53 |
| August 6 | Below mouth of Heim Creek | 790 | 10 | 8.0 | .80 |
| August 7 | do | 790 | 10 | 8.0 | .80 |
| Do | Above mouth of Heim Creek | 800 | 6 | 4.9 | .82 |

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## CHATANIKA RIVER DRAINAGE BASIN.

### GENERAL DESCRIPTION.

Chatanika River is formed by the junction of Faith and McManus creeks, which drain the high ridge forming the divide between the lower Tanana and Yukon basins. The river flows through a long and rather narrow valley in a southwesterly direction and is tributary to the Tolovana from the east, about 30 miles above the confluence of that stream with the Tanana. Its course lies mostly to the western side of the valley, which is from one-half mile to 7 miles in width. The valley is about 80 miles in length and heavily covered with timber below an altitude of 1,800 to 2,000 feet. The river has a drainage area of approximately 1,300 square miles above its mouth.

From the junction of Faith and McManus creeks the stream flows in a winding course and has a shifting, gravelly bottom. In low and medium stages it flows in a series of pools and rapids and has a width of 75 to 200 feet, and during the high-water period it often seeks several channels and covers a width of 100 to 400 feet. This high-water channel is usually well defined by steep, alluvial banks ranging from 8 to 10 feet in height.

Below Poker Creek, a tributary from the right about 40 miles downstream from the junction, the valley widens and the bottom lands become marshy and swampy. Here, from the left, the Chatanika receives the drainage from Cleary, Eldorado, Dome, Vault, and other less important streams from the mining district proper. Below these tributaries the valley narrows to a gorgelike channel which it follows for about 10 miles. Below this gorge the dividing ridges disappear and the stream meanders through the low, swampy grounds to the north of Tanana River. About 10 miles from its mouth Goldstream Creek, its largest tributary, joins it from the left.

The average elevation of the divides in the upper drainage area of the Chatanika is between 3,000 and 4,000 feet above sea level, and the altitude of the ridges bounding the valley on the east and west is about 2,000 feet.

The tributary streams from the right are short and precipitous, flowing through V-shaped valleys; those from the left have less precipitous courses and broader valleys, and gradually lose themselves in the rather broad expanse of swamplike bottom lands which prevail on that side.

The altitude and drainage area of the upper Chatanika has attracted the attention of "outside" capital for some time. The general topography has seemed suitable for a possible water supply by ditch line to the mining district proper, and the favorable slope of portions of Faith and McManus creeks has made them attractive to the promoter for hydraulicking.

Several gaging stations were established in this drainage basin during 1907. In June A. D. Gassaway, general manager of the Chatanika Ditch Company, began the first records of actual stream flow in this section by establishing gaging weirs at the mouth of Faith and McManus creeks.

Through the courtesy of this company, the records are published on page 117 in this report.

### FAITH CREEK.

Faith Creek, the right fork of Chatanika River, has its source in the southeasterly slope of the high ridges separating the Beaver and Birch Creek drainage basin from that of the Chatanika. It has a rather narrow, irregular valley, very steep in its upper course, and drains an area of 51 square miles.

The following measurements were made in its upper drainage basin July 11, 1907.

Hope Creek near the mouth of Zephyr Creek: Discharge, 7.7 second-feet; run-off, 0.42 second-foot per square mile.

Charity Creek about 1 mile above the mouth of Hope Creek: Discharge, 5.7 second-feet; run-off, 0.76 second-foot per square mile.

In the upper portion of the valley considerable glacial ice remains as late as the middle of July, especially in Charity Creek. Below the mouth of Deep Creek, a tributary from the right in the lower valley, there is a favorable reservoir site and with a moderate-sized dam a considerable amount of the flood waters could be stored.

The Chatanika Ditch Company established a gaging weir at the mouth of Faith Creek in 1907, and daily records were kept subsequent to June 21.

*Daily discharge, in second-feet, of Faith Creek at weir near mouth, 1907.*

[Elevation, 1,375 feet. Drainage area, 51 square miles.]

| Day. | June. | July. | Aug. | Sept. | Day. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | 32.6 | 36.4 | 59.0 | 20 | 44.7 | 43.9 | 27.8 | |
| 2 | | 28.5 | 41.1 | 52.5 | 21 | 44.7 | 38.6 | 26.9 | |
| 3 | | 26.4 | 35.9 | 50.2 | 22 | 42.8 | 31.4 | 44.2 | |
| 4 | | 24.8 | 34.7 | 66.4 | 23 | 39.3 | 25.5 | 39.4 | |
| 5 | | 22.1 | 42.5 | | 24 | 38.8 | 28.8 | 49.8 | |
| 6 | | 21.6 | 40.6 | | 25 | 35.3 | 26.4 | 62.8 | |
| 7 | | 22.0 | 87.4 | | 26 | 36.5 | 61.0 | 82.6 | |
| 8 | | 20.8 | 62.7 | | 27 | 34.4 | 42.0 | 69.3 | |
| 9 | | 20.1 | 52.4 | | 28 | 45.9 | 28.4 | 62.6 | |
| 10 | | 19.2 | 44.2 | | 29 | 43.6 | 30.6 | 70.5 | |
| 11 | | 21.0 | 39.0 | | 30 | 36.8 | 26.7 | 72.5 | |
| 12 | | 20.5 | 35.0 | | 31 | | 25.0 | 67.8 | |
| 13 | | 20.1 | 42.8 | | | | | | |
| 14 | | 21.0 | 35.6 | | Mean | [a]40.5 | 29.2 | 47.5 | |
| 15 | | 20.9 | 33.6 | | Run-off per square mile | .795 | .572 | .932 | |
| 16 | | 21.7 | 34.4 | | Run-off, depth in inches | .32 | .66 | 1.07 | |
| 17 | | 35.3 | 30.8 | | | | | | |
| 18 | | 35.0 | 30.6 | | | | | | |
| 19 | | 62.5 | 28.5 | | | | | | |

[a] June 20 to 30.

NOTE.—These data were furnished by the Chatanika Ditch Company.

## MCMANUS CREEK.

McManus Creek, the left fork of Chatanika River, rises in a somewhat lower divide than Faith Creek, though Idaho and Montana forks reach well up toward the headwaters of Homestake and Charity creeks, of the Faith Creek drainage basin. The main fork and Pool and Smith creeks, which are tributary to McManus Creek near its mouth, interlock with the headwaters of Birch Creek, a tributary to the Yukon and with the West Fork of the Chena, a tributary to the Tanana. The streams in the McManus Creek basin are not so precipitous as the tributaries of Faith Creek, and the run-off per square mile is less. There are one or two possible reservoir sites in this basin, but they are not as favorable as those on Faith Creek. The drainage area above the mouth of McManus Creek is 80 square miles.

A gaging weir was established near the mouth of McManus Creek about June 22, 1907, by the Chatanika Ditch Company and regular readings were taken subsequent to that date. The following measurements were made in this drainage basin in 1907:

*Discharge measurements in drainage basin of McManus Creek, 1907.*

| Date. | Point of measurement. | Elevation.[a] | Drainage area. | Discharge. | Run-off per square mile. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. miles.* | *Sec.-ft.* | *Sec.-ft.* |
| July 10 | McManus Creek at mouth | 1,375 | 80 | 15.6 | 0.195 |
| Do. | ....do | 1,375 | 80 | 16.4 | .205 |
| July 12 | McManus Creek above Smith Creek | 1,400 | 42.8 | 10.2 | .243 |
| Do. | Smith Creek near mouth | ,400 | 34 | 7.8 | .229 |
| Do. | McManus Creek at mouth | 1,375 | 80 | 15.6 | .192 |
| July 13 | McManus Creek ¾ mile above Montana Creek. | 2,000 | 8 | 1.8 | .162 |
| Do. | McManus Creek below Montana Creek. | 1,975 | 10 | 3.8 | .380 |
| Do. | McManus Creek 1½ miles below Idaho Creek. | 1,800 | 26 | 6.5 | .250 |
| Do. | McManus Creek ½ mile above mouth | 1,390 | ..... | [b]21.4 | ..... |
| July 14 | McManus Creek 500 feet above Smith Creek. | 1,400 | 42 | 12.4 | .296 |
| Do. | Smith Creek near mouth | 1,400 | 34 | 8.7 | .256 |
| Do. | Smith Creek above Pool Creek | 1,450 | 17 | 5.4 | .323 |
| Do. | Pool Creek above mouth | 1,450 | 14 | 2.4 | .172 |
| Do. | McManus Creek above mouth | 1,380 | ..... | [b]19.4 | ..... |

[a] Taken from topographic map of Fairbanks quadrangle; approximate only.
[b] Measurement approximate.

*Daily discharge, in second-feet, of McManus Creek at weir near mouth, 1907.*

[Elevation, 1,375. Drainage area, 80 square miles.]

| Day. | June. | July. | Aug. | Sept. | Day. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 21.6 | 81.2 | 71.5 | 20 | 34.8 | 31.6 | 33.6 | ..... |
| 2 | ..... | 20.1 | 80.8 | 62.8 | 21 | 34.8 | 26 | 32.2 | ..... |
| 3 | ..... | 19 | 56.1 | 57.8 | 22 | 31.2 | 21.2 | 68.7 | ..... |
| 4 | ..... | 18.5 | 51.2 | 57.2 | 23 | 34.8 | 17.8 | 50.3 | ..... |
| 5 | ..... | 17.8 | 63.4 | ..... | 24 | 25 | 21.4 | 67.1 | ..... |
| 6 | ..... | 16.1 | 60.6 | ..... | 25 | 21.7 | 19.1 | 81.2 | ..... |
| 7 | ..... | 17.5 | 98.6 | ..... | 26 | 25 | 38.6 | 102 | ..... |
| 8 | ..... | 17.8 | 84.3 | ..... | 27 | 24.3 | 29.1 | 92.6 | ..... |
| 9 | ..... | 15.8 | 75.6 | ..... | 28 | 31.1 | 23.9 | 91.2 | ..... |
| 10 | ..... | 15.0 | 77.8 | ..... | 29 | 26 | 21.8 | 114 | ..... |
| 11 | ..... | 16.1 | 62.2 | ..... | 30 | 23.2 | 18.8 | 112 | ..... |
| 12 | ..... | 15 | 49.8 | ..... | 31 | ..... | 16.7 | 94.1 | ..... |
| 13 | ..... | 15.4 | 45.5 | ..... | | | | | |
| 14 | ..... | 17.8 | 40.0 | ..... | Mean | [a] 28.5 | 21.4 | 66.4 | ..... |
| 15 | ..... | 18.5 | 37.2 | ..... | Run-off per | | | | |
| 16 | ..... | 19 | 42.4 | ..... | square mile | .356 | .268 | .830 | ..... |
| 17 | ..... | 21.6 | 39.0 | ..... | Run-off, depth | | | | |
| 18 | ..... | 34.7 | 37.4 | ..... | in inches | .15 | .31 | .96 | ..... |
| 19 | ..... | 40 | 34.7 | ..... | | | | | |

[a] June 20 to 30.

NOTE.—These data were furnished by the Chatanika Ditch Company.

## CHATANIKA RIVER NEAR JUNCTION OF FAITH AND MCMANUS CREEKS.

A gaging station was established July 16, 1907, on the Chatanika about 2,000 feet below the confluence of Faith and McManus creeks, and readings were taken twice each day by M. T. Kerrick, an employee of the Chatanika Ditch Company. The drainage area above this point is 132 square miles.

*Discharge measurements of Chatanika River near junction of Faith and McManus creeks, 1907.*

| Date. | Hydrographer. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| July 16 | C. C. Covert | 47 | 58 | 1.58 | 51.9 |
| July 26 | E. B. Brigham | 56 | 68 | 1.80 | 80.5 |
| August 3 | do | 57 | 72 | 1.89 | 96.5 |
| August 7 | do | 62 | 98 | 2.26 | 188 |

*Daily gage height and discharge of Chatanika River near junction of Faith and McManus creeks, 1907.*

[Elevation 1,350 feet; drainage area 132 square miles.]

| Day. | July. | | August. | | Day. | July. | | August. | |
|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | 1.80 | 80 | 19 | 1.80 | 80 | 1.75 | 73 |
| 2 | ..... | ..... | 2.02 | 122 | 20 | 1.75 | 73 | 1.75 | 73 |
| 3 | ..... | ..... | 1.86 | 92 | 21 | 1.70 | 66 | 1.75 | 73 |
| 4 | ..... | ..... | 1.93 | 101 | 22 | 1.62 | 57 | 1.98 | 111 |
| 5 | ..... | ..... | 1.95 | 106 | 23 | 1.60 | 54 | 1.92 | 101 |
| 6 | ..... | ..... | 1.95 | 106 | 24 | 1.64 | 60 | 2.04 | 122 |
| 7 | ..... | ..... | 2.25 | 186 | 25 | 1.75 | 73 | 2.22 | 177 |
| 8 | ..... | ..... | 2.12 | 147 | 26 | 1.85 | 88 | 2.25 | 186 |
| 9 | ..... | ..... | 2.05 | 128 | 27 | 1.75 | 73 | 2.15 | 154 |
| 10 | ..... | ..... | 2.02 | 122 | 28 | 1.67 | 63 | 2.13 | 147 |
| 11 | ..... | ..... | 1.92 | 101 | 29 | 1.65 | 60 | 2.25 | 186 |
| 12 | ..... | ..... | 1.85 | 88 | 30 | 1.60 | 54 | 2.25 | 186 |
| 13 | ..... | ..... | 1.85 | 88 | 31 | 1.60 | 54 | ..... | 186 |
| 14 | ..... | ..... | 1.80 | 80 | | | | | |
| 15 | ..... | ..... | 1.80 | 80 | Mean | | [a] 67 | ..... | 117 |
| 16 | ..... | ..... | 1.80 | 80 | Run-off, per square mile. | | .508 | ..... | .887 |
| 17 | 1.65 | 60 | 1.80 | 80 | Run-off, depth in inches. | | .29 | ..... | 1.02 |
| 18 | 1.86 | 90 | 1.78 | 78 | | | | | |

[a] July 17 to 31.

NOTE.—For September: Maximum, 1,770 second-feet; minimum, 110 second-feet; mean, 297 second-feet.

The following table gives the horsepower (80 per cent efficiency) per foot of fall that may be developed at different rates of discharge, and shows the number of days on which the discharge and the corresponding horsepower were respectively less than the amounts given in the columns for "discharge" and "horsepower."

*Discharge and horsepower table for Chatanika River near junction of Faith and McManus creeks, 1907.*

| Discharge. | Horsepower (80 per cent efficiency) per foot fall. | Days of deficient discharge, June 16 to August 31. | Discharge. | Horsepower (80 per cent efficiency) per foot fall. | Days of deficient discharge, June 16 to August 31. |
|---|---|---|---|---|---|
| *Sec.-ft.* | | | *Sec.-ft.* | | |
| 33 | 3 | ..... | 99 | 9 | 56 |
| 44 | 4 | 13 | 110 | 10 | 62 |
| 55 | 5 | 19 | 125 | 11.3 | 63 |
| 66 | 6 | 30 | 143 | 13 | 67 |
| 77 | 7 | 40 | 165 | 15 | 72 |
| 88 | 8 | 48 | 220 | 20 | ..... |

NOTE.—The discharge from June 16 to 25 is estimated from float measurements; from June 25 to July 17 from discharge over weirs at the mouth of Faith and McManus creeks.

## BOSTON CREEK.

Boston Creek rises in the high ridge to the north of the Chatanika, to which it is tributary, about 24 miles below Faith Creek. It is about 5 miles long and has a total fall of about 2,000 feet. The following measurement was made on this creek August 15, 1907, at an elevation of about 800 feet: Discharge, 3.9 second-feet; drainage area, 6.5 square miles; run-off, 0.60 second-foot per square mile.

### MCKAY CREEK.

McKay Creek is the first stream to the west of Boston Creek, rises in the same divide, and empties into the Chatanika about 1 mile farther downstream. It is about 4 miles long and flows through a narrow, V-shaped valley. It has a drainage area of 6.7 square miles. The following measurement was made on this stream August 15, 1907, at an elevation of about 800 feet: Discharge, 3.7 second-feet; drainage area, 6.2 square miles; run-off, 0.602 second-foot per square mile.

### BELLE CREEK.

Belle Creek rises in the high divide at the head of Ophir and Poker creeks and flows in a southeasterly direction to the Chatanika. The stream is about 6 miles long and flows through a deep, narrow valley. It drains an area of 11.9 square miles. A measurement was made on this stream August 15, 1907, at an elevation of about 800 feet, as follows: Discharge, 10 second-feet; drainage area, 11 square miles; run-off, 0.91 second-foot per square mile.

### CROOKED CREEK.

Crooked Creek rises in the divide at the head of Poker Creek and flows in a southeasterly direction nearly parallel to Belle Creek. It drains an area of 7.2 square miles. A measurement was made near its mouth August 15, 1907, as follows: Discharge, 6.3 second-feet; drainage area, 7.2 square miles; run-off, 0.875 second-foot per square mile.

### KOKOMO CREEK.

Kokomo Creek, a tributary to Chatanika River from the left about 28 miles below Faith Creek, rises in the high ridge at the head of Miller and Elliot creeks and flows in a northwesterly direction, draining an area of 33 square miles above its mouth. Daily readings were taken from a reference point in a large stump on the river bank about 1 mile above the mouth of the stream.

*Discharge measurements of Kokomo Creek near mouth, 1907.*

| Date. | Gage height.[a] | Discharge. |
|---|---|---|
| | *Feet.* | *Sec.-ft.* |
| July 9 | −3.00 | 13.9 |
| August 14 | −2.70 | 22.7 |

[a] Measured down from nail in stump.

*Daily gage height and discharge of Kokomo Creek near mouth, 1907.*

[Elevation, 750 feet; drainage, area 26 square miles.]

| Day. | July. | | August. | | Day. | July. | | August. | |
|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | ..... | ..... | +0.9 | 112 | 19 | 3.0 | 13.9 | ..... | ..... |
| 2 | ..... | ..... | −1.2 | 68 | 20 | 3.0 | 13.9 | ..... | ..... |
| 3 | ..... | ..... | 2.0 | 43.8 | 21 | 3.0 | 13.9 | ..... | ..... |
| 4 | ..... | ..... | 2.2 | 37.9 | 22 | 3.1 | 10.9 | ..... | ..... |
| 5 | ..... | ..... | 2.4 | 31.8 | 23 | 3.2 | 7.9 | ..... | ..... |
| 6 | ..... | ..... | 2.4 | 31.8 | 24 | 3.0 | 13.9 | ..... | ..... |
| 7 | ..... | ..... | 2.3 | 34.8 | 25 | 3.1 | 10.9 | ..... | ..... |
| 8 | ..... | ..... | 2.4 | 31.8 | 26 | 3.0 | 13.9 | ..... | ..... |
| 9 | −3.0 | 13.9 | 2.0 | 43.8 | 27 | 3.0 | 13.9 | ..... | ..... |
| 10 | 3.1 | 10.9 | 2.2 | 37.9 | 28 | 3.0 | 13.9 | ..... | ..... |
| 11 | 2.6 | 25.8 | 2.4 | 31.8 | 29 | 3.1 | 10.9 | ..... | ..... |
| 12 | 2.8 | 19.8 | 2.5 | 28.9 | 30 | 3.2 | 7.9 | ..... | ..... |
| 13 | 2.8 | 19.8 | 2.6 | 25.8 | 31 | 3.2 | 7.9 | ..... | ..... |
| 14 | 2.9 | 16.8 | 2.7 | 22.7 | | | | | |
| 15 | 2.9 | 16.8 | ..... | ..... | Mean | | [a] 14.2 | ..... | [b] 41.6 |
| 16 | 2.9 | 16.8 | ..... | ..... | Run-off per square mile | | .546 | ..... | 1.60 |
| 17 | 3.0 | 13.9 | ..... | ..... | Run-off, depth in inches | | .47 | ..... | .83 |
| 18 | 2.8 | 19.8 | ..... | ..... | | | | | |

[a] July 9 to 31.

[b] August 1 to 14.

## POKER CREEK.

Poker Creek, with its tributary, Caribou Creek, rises in the high, barren ridges about Poker Dome and opposite the headwaters of Ophir, Trail, and Washington creeks. It drains an oval-shaped area of 40.5 square miles, well covered with timber, and has steep precipitous slopes in its upper course.

The Tanana Electric Company is constructing a ditch line along the left bank of Poker Creek, following approximately the 800-foot contour. This ditch line will divert water from Poker, Little Poker, and Caribou creeks to a point on the Chatanika where about 80 feet head can be obtained. It is proposed to install a power plant at this point, to be run by water when available, and by steam at other times.

*Discharge measurements in Poker Creek drainage basin, 1907.*

| Date. | Point of measurement. | Drainage area. | Gage height. | Discharge. | Run-off per square mile. |
|---|---|---|---|---|---|
| | | *Sq. miles.* | *Feet.* | *Sec.-ft.* | *Sec.-ft.* |
| July 27 | Poker Creek ½ mile above mouth | 40 | 1.09 | 22.3 | 0.558 |
| July 30 | do | 40 | 1.10 | 22.6 | .565 |
| August 9 | do | 40 | 1.32 | 36.6 | .915 |
| August 10 | do | 40 | 1.33 | 37.8 | .944 |
| Do | Caribou Creek above Little Poker Creek | ..... | ..... | 10.4 | ..... |
| Do | Little Poker Creek near mouth | ..... | ..... | 3.9 | ..... |
| Do | Poker Creek 1 mile above Caribou Creek | ..... | ..... | 21.1 | ..... |

## CHATANIKA RIVER BELOW MOUTH OF POKER CREEK.

A gaging station was established on Chatanika River below Poker Creek June 23, 1907. A post gage driven firmly in the ground near the log chute of the Cleary Creek Lumber Company's mill was read twice each day by J. Fitzsimmons.

*Discharge measurements of Chatanika River below mouth of Poker Creek, 1907.*

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-ft.* |
| June 22 | 88.5 | 213 | 1.08 | 246 |
| July 4 | 86.8 | 192 | .83 | 178 |
| August 9 | 98 | 302 | 1.98 | 669 |

*Daily gage height and discharge of Chatanika River below mouth of Poker Creek, 1907.*

[Elevation 700 feet; drainage area 456 square miles.]

| Day. | June. | | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 0.9 | 192 | 2.1 | 752 | 1.45 | 384 | 2.25 | 860 |
| 2 | | | .9 | 192 | 2.6 | 1,160 | 1.4 | 363 | 2.0 | 680 |
| 3 | | | .9 | 192 | 2.0 | 680 | 1.3 | 321 | 1.85 | 590 |
| 4 | | | .8 | 167 | 1.75 | 530 | 1.3 | 321 | 1.75 | 530 |
| 5 | | | .8 | 167 | 1.75 | 530 | 1.25 | 300 | 1.70 | 505 |
| 6 | | | .8 | 167 | 1.65 | 480 | 1.3 | 321 | 1.65 | 480 |
| 7 | | | .8 | 167 | 1.5 | 405 | 1.3 | 321 | 1.6 | 455 |
| 8 | | | .95 | 204 | 1.75 | 530 | 1.3 | 321 | 1.45 | 384 |
| 9 | | | .85 | 180 | 1.9 | 620 | 1.45 | 384 | 1.25 | 300 |
| 10 | | | .80 | 167 | 1.85 | 590 | 1.3 | 321 | 1.05 | 232 |
| 11 | | | .90 | 192 | 1.6 | 455 | 1.35 | 342 | 1.45 | 384 |
| 12 | | | .90 | 192 | 1.5 | 405 | 3.6 | [a] 2,160 | 1.85 | 590 |
| 13 | | | .95 | 204 | 1.35 | 342 | 4.45 | [a] 3,160 | 1.80 | 560 |
| 14 | | | .9 | 192 | 1.4 | 363 | 3.25 | [a] 1,780 | 1.75 | 530 |
| 15 | | | 1.0 | 216 | 1.25 | 300 | 2.85 | [a] 1,390 | | |
| 16 | | | 1.05 | 232 | 1.2 | 283 | 4.0 | [a] 2,620 | | |
| 17 | | | 1.10 | 250 | 1.1 | 250 | 4.3 | [a] 2,980 | | |
| 18 | | | 1.1 | 250 | 1.1 | 250 | 2.35 | 942 | | |
| 19 | | | 1.2 | 283 | 1.0 | 216 | 2.5 | 1 060 | | |
| 20 | 1.10 | 250 | 1.15 | 266 | 1.1 | 250 | 2.3 | 901 | | |
| 21 | 1.10 | 250 | 1.1 | 250 | 1.1 | 250 | 2.35 | 942 | | |
| 22 | 1.10 | 250 | 1.1 | 250 | 1.0 | 216 | 2.3 | 901 | | |
| 23 | 1.10 | 250 | .95 | 204 | 1.15 | 266 | 2.25 | 860 | | |
| 24 | 1.05 | 232 | .9 | 192 | 1.20 | 283 | 2.15 | 788 | | |
| 25 | 1.00 | 216 | .9 | 192 | 1.35 | 342 | 2.0 | 680 | | |
| 26 | .90 | 192 | 1.05 | 232 | 1.55 | 430 | 2.0 | 680 | | |
| 27 | .9 | 192 | 1.1 | 256 | 1.3 | 321 | 2.0 | 680 | | |
| 28 | 1.0 | 216 | 1.1 | 250 | 1.4 | 363 | 2.0 | 680 | | |
| 29 | 1.1 | 250 | 1.1 | 250 | 1.55 | 430 | 2.15 | 788 | | |
| 30 | 1.0 | 216 | 1.0 | 216 | 1.7 | 505 | 2.35 | 942 | | |
| 31 | | | .9 | 192 | 1.6 | 455 | | | | |
| Mean | | [b] 228 | | 211 | | 428 | | 954 | | [c] 506 |
| Second-feet per square mile | | .500 | | .463 | | .939 | | 2.09 | | 1.11 |
| Depth in inches | | .20 | | .53 | | 1.08 | | 2.33 | | .68 |

[a] Estimated by extending rating curve. [b] June 20 to 30. [c] October 1 to 14.

NOTE.—The river was frozen over after October 14.

### CLEARY CREEK.

Cleary Creek heads to the north of Pedro Dome in a rather low saddle which separates its waters from those of Little Eldorado Creek and which has an elevation of about 1,800 feet. It flows in a northerly direction for about 3 miles, then, by a gradual curve to the left, takes a northwesterly course to Chatanika River, to which it is tributary from the left about 2 miles below Poker Creek.

The creek has an average slope of about 90 feet to the mile through the mining section. It is considered the best producer in the camp. (See Pl. X.) The pay streak follows the creek channel closely about to claim 15 below. At that point it swings to the left bank, which it follows to the Chatanika Flats. (See Pl. XI, *A*.)

Cleary Creek has a drainage area of 10.5 square miles above its mouth. A measurement made July 4 near Cleary gave a discharge of 2.9 second-feet.

### LITTLE ELDORADO CREEK.

Little Eldorado Creek rises on the western slope of Pedro Dome and drains a rather narrow valley between Dome and Vault creeks. It has a steep slope in its upper portion. The average fall of the creek through the mining section is 115 feet per mile. It is about 5 miles long and drains an area of 13.7 square miles. The creek flows in a narrow, rather deep-cut channel, well lined with willows.

The pay streak is on the right bank and is located from claim 7 above to claim 4 below. Bed rock ranges from 90 to 122 feet below the surface, with 10 to 80 feet of gravel. The following measurement was made June 26, 1907: Discharge, 0.45 second-foot, elevation, 930 feet; drainage area, 4 square miles; run-off, 0.112 second-foot per square mile.

### DOME CREEK.

Dome Creek rises in the Chatanika divide, opposite Steamboat and Flume creeks, and flows northward into Chatanika River. It is about 5 miles long and drains an area of 13.9 square miles. The creek has an average grade through the mining section of about 70 feet to the mile and good values are found in its upper and lower courses. Discovery claim is located on the right bank near the town of Dome. The creek is being worked on several claims from 7 above to 20 below. The pay streak is on the right bank for practically its entire length. Bed rock ranges from 40 feet below the surface in the upper portion to more than 200 feet below in the Chatanika Flats, near the mouth. Very little water flows in the main channel during the low-water period, a large part of the flow being diverted by numer-

MINING OPERATIONS ON CLEARY CREEK.

ous small ditches. A measurement, made June 27, 1907, in a ditch near claim 2 below, gave an approximate discharge of 0.84 second-foot.

## GOLDSTREAM CREEK DRAINAGE BASIN.

### GENERAL DESCRIPTION.

Goldstream Creek flows through a long, narrow valley between the drainage basin of Chatanika River on the right and the Little Chena and Tanana basins on the left. It has a southwesterly direction, paralleling Chatanika River, and drains the central portion of the Fairbanks mining district. The stream flows in a winding course over a sandy, shifting bed. The channel is deeply cut in the alluvial soil that forms the bottom lands. Its length is about 70 miles and it drains an area of 500 square miles. About 40 miles below its source the stream leaves the dividing ridges and for the remainder of its course flows in a zigzag channel across the soft, mucky flats northwest of Tanana River, emptying into the Chatanika from the east.

On either side of the stream is a narrow lowland having a gradual slope toward the dividing ridges. This is covered with the conventional moss, and in the lower portion of the valley, where it widens, has numerous lakes and swamps. The bottom land has been well covered with timber, but this has disappeared to make way for railroad and mining enterprises, which make the upper portion of the valley a scene of activity. The dividing ridges on either side are well timbered with spruce and birch and rise about 1,000 feet above the stream bed. About 12 miles below the source, the southern ridge has a low saddle over which the Tanana Mines Railroad from Fairbanks enters the mining district.

The upper portion of the valley is drained by Pedro and Gilmore creeks, which join to form Goldstream Creek near Gilmore, about 12 miles north of Fairbanks.

Pedro Creek, the right fork of Goldstream Creek, is about 6 miles long and has a fall of 100 to 200 feet to the mile in its upper course. About 3 miles from its source Twin Creek, a tributary from the right, enters. Here, in 1902, gold was first found in the Fairbanks district, by Felix Pedro. Below this point the creek has a grade of about 80 feet to the mile, which gradually grows less as it approaches Goldstream Creek. Along Pedro Creek the pay streak follows the stream channel closely and bed rock is from 10 to 30 feet below the surface.

On Goldstream Creek the pay streak is along the right bank about to claim 10 below and then swings to the left bank, which it follows about to claim 22 below. Farther than this, it has not been

definitely located. The depth to bed rock ranges from 20 to 60 feet.

Gilmore Creek, the left fork of Goldstream Creek, has shown small values and very little work is in progress. The creek has a fairly good grade and drains an area of 11.8 square miles.

There are numerous small tributaries to Goldstream Creek from either side. Those from the right are Fox, Gold Run, Big Eldorado, O'Connor, and Cache creeks. Those from the left are Engineer, Butter, Spear, Nugget, Straight, and Allen creeks. Prospecting and more or less mining is done on nearly all these creeks. They average from 4 to 12 miles in length and drain small areas.

On the upper portion of Goldstream Creek and along Pedro Creek several small ditches have been built to divert the water for sluicing. The largest one is that owned by the Goldstream Ditch Company. The cost of construction was about $6,500. It is about 2 miles in length and has a fall of about 7 feet to the mile. It diverts water from claim 6 below, along the left bank of Goldstream Creek, supplying several mines at the rate of $2 per hour per sluice head, which ranges from 60 to 80 inches of water. A measurement made June 28, 1907, in the lower end of a flume near the intake to this ditch gave a discharge of 10.8 second-feet.

### GOLDSTREAM CREEK AT CLAIM 6 BELOW.

On account of the unfavorable condition of the channel of Goldstream Creek and the numerous small ditches that divert the flow, it was impossible to secure a good location for a gaging station. However, a gage was established near the lower line of claim 6 below, a short distance above the intake to the Goldstream ditch, June 20, 1907, and a reading was taken twice each day by John L. Meder. The water diverted by a small ditch a short distance above the gaging station is not considered in the table of estimates. Several measurements made in this ditch gave an average discharge of 1.5 second-feet.

*Discharge measurements of Goldstream Creek at claim 6 below, 1907.*

| Date. | Width. | Area of section. | Gage height. | Discharge. |
|---|---|---|---|---|
| | *Feet.* | *Sq. ft.* | *Feet.* | *Sec.-feet.* |
| June 21 | 11.3 | 8.1 | 1.00 | 10.8 |
| June 28 | 12.4 | 10.3 | 1.31 | 21.1 |

*A.* LOWER CLEARY CREEK.

*B.* GAGING STATION ON FISH CREEK.

*Daily gage height and discharge of Goldstream Creek at claim 6 below, 1907.*

[Elevation, 870 feet; drainage area, 28.6 square miles.]

| Day. | June. | | July. | | August. | | September. | | October. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. | Gage height. | Discharge. |
| | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* | *Feet.* | *Sec.-ft.* |
| 1 | | | 1.3 | 20.7 | 1.55 | 30.2 | 1.25 | 18.9 | 1.3 | 20.7 |
| 2 | | | 1.05 | 12.3 | 1.6 | 32.2 | 1.20 | 17.1 | 1.3 | 20.7 |
| 3 | | | 1.0 | 10.8 | 1.3 | 20.7 | 1.20 | 17.1 | 1.4 | 24.4 |
| 4 | | | .95 | 9.3 | 1.15 | 15.4 | 1.25 | 18.9 | 1.3 | 20.7 |
| 5 | | | .8 | 4.9 | 1.1 | 13.8 | 1.30 | 20.7 | 1.3 | 20.7 |
| 6 | | | .75 | 3.6 | 1.15 | 15.4 | 1.2 | 17.1 | 1.3 | 20.7 |
| 7 | | | 1.15 | 15.4 | 1.4 | 24.4 | 1.2 | 17.1 | 1.2 | 17.1 |
| 8 | | | 1.05 | 12.3 | 1.45 | 26.3 | 1.15 | 15.4 | | |
| 9 | | | 1.0 | 10.8 | 1.35 | 22.5 | 1.2 | 17.1 | | |
| 10 | | | .85 | 6.4 | 1.6 | 32.2 | 1.15 | 15.4 | | |
| 11 | | | 1.6 | 32.2 | 1.45 | 26.3 | 1.35 | 22.5 | | |
| 12 | | | 1.55 | 30.2 | 1.15 | 15.4 | 1.7 | 36.6 | | |
| 13 | | | 1.2 | 17.1 | 1.1 | 13.8 | 1.7 | 36.6 | | |
| 14 | | | 1.1 | 13.8 | 1.05 | 12.3 | 1.5 | 28.2 | | |
| 15 | | | 1.65 | 34.4 | 1.05 | 12.3 | 1.5 | 28.2 | | |
| 16 | | | 1.5 | 28.2 | 1.1 | 13.8 | 1.8 | 41. | | |
| 17 | | | 1.25 | 18.9 | 1.0 | 10.8 | 1.55 | 30.2 | | |
| 18 | | | 1.15 | 15.4 | 1.0 | 10.8 | 1.45 | 26.3 | | |
| 19 | | | 1.05 | 12.3 | 1.0 | 10.8 | 1.3 | 20.7 | | |
| 20 | 1.0 | 10.8 | 1.05 | 12.3 | 1.1 | 13.8 | 1.6 | 32.2 | | |
| 21 | 1.0 | 10.8 | 1.0 | 10.8 | 1.25 | 18.9 | 1.45 | 26.3 | | |
| 22 | .95 | 9.3 | .95 | 9.3 | 1.3 | 20.7 | 1.4 | 24.4 | | |
| 23 | .8 | 4.9 | .9 | 7.8 | 1.3 | 20.7 | 1.55 | 30.2 | | |
| 24 | .9 | 7.8 | 1.05 | 12.3 | 1.3 | 20.7 | 1.45 | 26.3 | | |
| 25 | .9 | 7.8 | .95 | 9.3 | 1.25 | 18.9 | 1.4 | 24.4 | | |
| 26 | 1.05 | 12.3 | .95 | 9.3 | 1.35 | 22.5 | 1.4 | 24.4 | | |
| 27 | .85 | 6.4 | .85 | 6.4 | 1.3 | 20.7 | 1.3 | 20.7 | | |
| 28 | 1.3 | 20.7 | .85 | 6.4 | 1.35 | 22.5 | 1.25 | 18.9 | | |
| 29 | 1.55 | 30.2 | .8 | 4.9 | 1.45 | 26.3 | 1.35 | 22.5 | | |
| 30 | 1.45 | 26.3 | .8 | 4.9 | 1.5 | 28.2 | 1.4 | 24.4 | | |
| 31 | | | .7 | 2.2 | 1.5 | 28.2 | | | | |
| Mean | | [a]13.4 | | 13.1 | | 20. | | 24. | | [b]20.7 |
| Run-off per square mile | | .469 | | .458 | | .699 | | .839 | | .724 |
| Run-off, depth in inches | | .192 | | .53 | | .81 | | .94 | | .19 |

[a] June 20 to 30.

[b] October 1 to 7.

NOTE.—These discharges do not include the amount diverted at claim 3 below by a small ditch, carrying from 1 to 1.5 second-feet. The creek was frozen after October 7.

### FOX CREEK.

Fox Creek rises in the Chatanika divide opposite Vault Creek. It is about 3½ miles long and flows southward, through a V-shaped valley, into Goldstream Creek. The following measurement was made July 6, 1907: Discharge, 2.0 second-feet; elevation, 900 feet.

## BEAVER CREEK DRAINAGE BASIN.

### GENERAL DESCRIPTION

A high limestone ridge—the White Mountains—50 miles to the north of Fairbanks, is perhaps the highest portion of the divide between the Yukon and Tanana drainage basins. Beaver Creek,

which drains the largest part of this particular portion of the divide, has its source far back in the deep canyons of the southern slope. There are two branches of Beaver Creek in its upper drainage basin that join at about latitude 65° 25′ north, and longitude 147° west. These two branches drain the highest portion of the mountains. The southern branch rises in a high ridge opposite the tributaries of Preacher Creek. It has a steep and tortuous course, flowing over a rocky bed and through a deep valley. The northern or main branch of Beaver Creek drains to the south the central portion of the mountain ridge. The gorgelike valley of the upper portion of this branch runs in an east-west direction and forms with the main valley a letter T. The course of the northern branch is tortuous and the bed is rough and gravelly. In the valley at the junction of these two branches some timber is found, and there are also small patches of meadow land. From the junction the main stream takes a westerly course for about 25 miles, then makes an abrupt bend to the right and flows in a northeasterly direction, draining the northern slope of the White Mountains. Its course above the "big bend" is through a rather broad, parklike valley, over a wide gravelly bed, in a series of riffles and pools. This portion of the stream, with its tributaries, drains the southern slope of the White Mountains. In many places the stream has several channels, forming numerous islands which are usually covered with a heavy growth of timber.

Bear and Bryan creeks are the important tributaries from the right. High, barren limestone ridges separate these creeks and form deep, narrow, gorgelike valleys, through which the streams flow over precipitous, narrow beds.

There is but little timber on the slopes of the mountains except in the lower course of the stream, and here the average size is smaller than that of the timber in the Chatanika and Little Chena basins.

The southern tributaries of Beaver Creek above the big bend are Nome, Ophir, Trail, and Wickersham creeks, whose upper portions drain the dividing ridge to the north of Chatanika River. These streams have more gradual slopes than the northern tributaries, and flow through rather narrow channels cut deep into the soft, alluvial soil of which their bottom lands consist. The ridges separating these creeks are at a much lower elevation than those on the northern slope. They are covered with timber and the many small streams which drain their slopes are fed by numerous springs. The general direction of these streams, with the exception of Nome Creek, is to the northwest—a course almost opposite to that of the main creek which receives their black, tranquil waters.

The upper portion of the Beaver Creek drainage basin is oval in shape and rises to an elevation of 1,800 to 4,000 feet. A portion of

the easterly divide has an altitude of 5,000 feet. About 8 miles below the "big bend" Fossil Creek enters Beaver Creek from the right through a deep, narrow canyon. It drains a long, narrow valley of rather high elevation, and rises on the northern slope of Cache Mountain, which has an elevation of over 4,000 feet and separates the Fossil Creek drainage basin from that of Bryan Creek. Fossil Creek flows in a northerly direction for 5 or 6 miles, makes a long, easy curve to the left, flows around the northern foothills, and finally takes a southwesterly course close to the high limestone ridge that separates it from Beaver Creek.

In the upper portion of the Fossil Creek basin, on the right-hand side, there is a marked case of stream piracy. A small stream reaches into the right-hand part of the basin and takes a portion of the drainage through a gorge of high elevation into Beaver Creek, about 12 miles below the mouth of Fossil Creek

Victoria Creek, a tributary from the left about 20 miles below Fossil Creek, has its source nearly opposite Cache Mountain and is separated from Beaver Creek, which it parallels for about 50 miles, by a limestone ridge ranging from 1,000 to nearly 3,000 feet above the bed of the stream.

Some distance below the mouth of Victoria Creek, Beaver Creek changes its course to the left and flows in a northwesterly direction through a less mountainous country to the Yukon.

Beaver Creek has every indication of furnishing a good water supply. Its high drainage basin makes its waters desirable for either hydraulicking or power development. Although the present location of the mining camps is at a prohibitive distance for ditch lines, future developments may make valuable any information concerning the daily flow and run-off in this drainage basin.

## MEASUREMENTS.

The following miscellaneous measurements were made in Beaver Creek drainage basin:

*Miscellaneous measurements in Beaver Creek drainage basin, 1907.*

| Date. | Stream. | Approximate elevation. | Drainage area. | Discharge. | Run-off per square mile. |
|---|---|---|---|---|---|
| | | *Feet.* | *Sq. miles.* | *Sec.-ft.* | *Sec.-ft.* |
| August 27 | Trail Creek | 1,700 | 27 | 39.9 | 1.48 |
| Do | Brigham Creek | 1,500 | 15 | 16.0 | 1.06 |
| August 28 | Fossil Creek | 1,300 | ..... | 19.2 | ..... |
| August 29 | Bryan Creek | 1,800 | 48 | 75.3 | 1.57 |
| August 30 | Beaver Creek above East Branch | 1,800 | 122 | 267 | 2.19 |
| Do | East Branch Beaver Creek above mouth | 1,800 | 67 | 124 | 1.85 |
| Do | Nome Creek near mouth | 1,700 | 120 | 135 | 1.12 |

## COMPARATIVE RUN-OFF OF DIFFERENT AREAS.

In order to afford a comparison of the run-off of different drainage areas in 1907, the following tables have been prepared, showing the minimum daily flow, the monthly means in second-feet per square mile, and the mean weekly flow of the drainage areas investigated. These tables can be used in estimating the run-off of other streams in this section having similar areas. Considerable care should be used in making such estimates, on account of local conditions affecting the run-off.

*Minimum daily flow of streams in Fairbanks district, 1907.*

| Point of measurement. | Elevation. | Date. | Minimum flow. | Drainage area. | Minimum run-off per square mile. | Duration of record. | |
|---|---|---|---|---|---|---|---|
| | | | | | | From— | To— |
| | *Feet.* | | *Sec.-ft.* | *Sq. miles.* | *Sec.-ft.* | | |
| Little Chena River above Elliott Creek. | 800 | July 22–25, 29–31... | 42 | 79 | 0.53 | July 22 | Sept. 10 |
| Elliott Creek above Sorrels | 800 | July 31..... | 2.5 | 13.8 | .18 | ...do.... | Do. |
| Sorrels Creek above mouth | 800 | ...do ..... | 6 | 21 | .28 | ...do.... | Do. |
| Fish Creek above Fairbanks Creek. | 925 | July 30–31..... | 18 | 39 | .46 | ...do.... | Do. |
| Faith Creek at mouth ... | 1,400 | July 10..... | 19.2 | 51 | .38 | June 20 | Sept. 4 |
| McManus Creek at mouth. | 1,400 | July 10–12..... | 15 | 80 | .19 | ...do.... | Do. |
| Chatanika River below Faith Creek. | 1,350 | July 31..... | 54 | 132 | .41 | July 17 | Sept. 30 |
| Kokomo Creek near mouth. | 750 | July 23, 30–31..... | 7.9 | 26 | .30 | July 9 | Aug. 14 |
| Chatanika River below Poker Creek. | 700 | July 4–7, 10..... | 167 | 456 | .36 | June 20 | Oct. 14 |

*Mean run-off in second-feet per square mile at gaging stations in Fairbanks district, 1907.*

| Stream. | Elevation. | Drainage area. | June 20–30. | July 1–31. | July 22–31. | Aug. 1–31. | Sept. 1–31. | Sept. 1–10. | Oct. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *Sq. miles.* | | | | | | | |
| Little Chena | 800 | 79 | ..... | ..... | 0.62 | 1.08 | ..... | 1.09 | ..... |
| Elliott | 800 | 13.8 | ..... | ..... | .43 | .80 | ..... | .72 | ..... |
| Sorrels | 800 | 21 | ..... | ..... | .50 | .87 | ..... | .76 | ..... |
| Fish Creek | 925 | 39 | ..... | ..... | .58 | .94 | ..... | .68 | ..... |
| Faith Creek | 1,400 | 51 | 0.80 | 0.57 | ..... | .93 | ..... | ..... | ..... |
| McManus | 1,400 | 80 | .36 | .27 | ..... | .83 | ..... | ..... | ..... |
| Chatanika River below Faith Creek | 1,350 | 132 | ..... | ..... | [a].51 | .89 | 2.18 | ..... | ..... |
| Chatanika River below Poker Creek | 700 | 456 | .50 | .46 | ..... | .94 | 2.09 | ..... | [b]1.11 |
| Goldstream Creek | 870 | 28.6 | .47 | .46 | ..... | .70 | .84 | ..... | [c].72 |

[a] July 17–31. [b] October 1–10. [c] October 1–7.

*Mean weekly water supply, in second-feet, from Little Chena and Chatanika River basins, 1907.*

| Date. | Available for use by diversion at elevation 1,350 feet. | Available for use by pumping at elevation 700 feet. | Available for use by diversion at elevation 800 to 925 feet. | | | | |
|---|---|---|---|---|---|---|---|
| | Chatanika River near Faith Creek. | Chatanika River below mouth of Poker Creek. | Little Chena River above Elliott Creek. | Elliott Creek above Sorrels Creek. | Sorrels Creek above mouth. | Fish Creek above Fairbanks. | Total in Little Chena drainage basin. |
| June 17–23 | 86 | | | | | | |
| June 24–30 | 64 | 216 | | | | | |
| July 1–7 | 44 | 178 | | | | | |
| July 8–14 | 36 | 190 | | | | | |
| July 15–21 | 64 | 250 | | | | | |
| July 22–28 | 70 | 224 | 52 | 7 | 12 | 24 | 95 |
| July 29–August 4 | 80 | 540 | 80 | 12 | 18 | 55 | 165 |
| August 5–11 | 128 | 516 | 110 | 12 | 24 | 42 | 188 |
| August 12–18 | 82 | 313 | 73 | 10 | 16 | 26 | 125 |
| August 19–25 | 104 | 260 | 56 | 6 | 10 | 24 | 96 |
| August 26–September 1 | 169 | 413 | 90 | 11 | 18 | 26 | 145 |
| September 2–8 | 120 | 324 | 82 | 9 | 15 | 26 | 132 |
| September 9–15 | 513 | 1,360 | | | | | |
| September 16–22 | 376 | 1,480 | | | | | |
| September 23–29 | 216 | 737 | | | | | |
| September 30–October 6 | | 655 | | | | | |
| October 7–13 | | 415 | | | | | |
| Mean | 143 | 504 | 78 | 10 | 16 | 32 | 136 |
| Maximum | 513 | 1,480 | 110 | 12 | 24 | 55 | 188 |
| Minimum | 36 | 190 | 52 | 6 | 10 | 24 | 95 |

## DEVELOPMENT OF WATER SUPPLY IN THE FAIRBANKS DISTRICT.

### GENERAL CONDITIONS.

Since the discovery of gold on Pedro Creek in the Fairbanks district in 1902, considerable attention has been given to this section of Alaska, and, with nearly a $9,000,000 output in 1906, renewed interest has centered in this region.

The camp lies at the southern edge of the plateau country, almost where it breaks to the alluvial plain. At the present time a large part of the area may be spoken of as in a prospective stage of development. Little attention has been given to the development of water supply for mining purposes. The work has been carried on either by "open cuts" or by "drifting," as best suits the local conditions. The upper portions of the creeks usually favor the "open cut" method, as the bed rock ranges only from 8 to 20 feet below the surface. In the lower reaches, where the pay streak is from 50 to 250 feet underground, with 25 to 200 feet of overburden, "drifting" seems the only solution. The work being underground, where protection from severe weather is assured, this portion of the camp is active in winter as well as in summer. The pay gravel is hoisted to the surface and dumped

in large piles, where it awaits the spring break-up for sluicing, when high water follows the melting of the accumulated snow. (See Pl. X, p. 122.)

The future development of this region, as of other mining districts in Alaska, depends largely on the economical development of its water resources. During July and part of August, 1907, the miners were obliged to resort to various schemes to secure sufficient water for sluicing. In some instances the water was returned for the second and third time to the sluice box by means of the steam pump, entailing extra expense both in fuel and equipment, and on a number of the creeks only about half of the mines were in operation.

### DITCH LINES.

In general the relation of the mining camp to the surrounding country is not favorable for obtaining an outside water supply by gravity. The topography of the country is such that ditch lines from the larger drainage areas are not altogether practical. The camp lies in three drainage basins or valleys, separated by high dividing ridges, and, in order to supply the producing creeks in one valley with water by ditch line from another, the ditch must have a high elevation, which throws its source so far into the headwaters that there is only a small drainage area from which to draw the supply and consequently but little water.

On account of its elevation, the upper Chatanika drainage basin has received more attention concerning the water supply by ditch line to the mining camps than any other drainage area within a reasonable distance of the Fairbanks district. The supply from this stream, however, would have to be conveyed for over 100 miles through a ditch line, difficult to construct and maintain, and on account of its low head only a small number of producing creeks would be benefited.

Numerous surveys and reports have been made favoring the construction of ditch lines from this drainage basin. The first plan proposed a ditch along the left bank of the Chatanika that would deliver water to Pedro Dome at an elevation of about 1,800 feet, which would be necessary in order to supply water to Goldstream and Fairbanks creeks on the other side of the divide. The intake of such a ditch would have an elevation of about 2,000 feet, or 600 feet higher than the mouth of Faith and McManus creeks, where records of stream flow were kept during the season of 1907. The drainage area above this intake would be about 100 square miles, or about 25 per cent less than at the point where measurements were made.

During 1907 surveys were made for a proposed ditch, with an intake at the junction of Faith and McManus creeks. This ditch

would deliver water to the camps at an elevation of about 1,200 feet—much too low to supply water outside of the Chatanika drainage basin. The table on page 129 shows the weekly supply that would have been available for such a ditch, and the table on page 132 shows the number of days of deficient flow without storage and the amount of storage necessary to have maintained in the ditch a flow of 75, 100, or 125 second-feet.

### WATER-POWER DEVELOPMENT.

Water-power development for electric transmission in the Fairbanks district seems worthy of consideration. The table on page 118 shows the horsepower (80 per cent efficiency) that could have been developed in 1907 from the water supply of the Chatanika at the junction of Faith and McManus creeks. This table shows also the duration in days for different rates of flow. The table on page 132 shows the storage that would have been necessary for the maintenance of a daily flow of 100 second-feet, which would furnish 9.1 horsepower per foot of fall.

By constructing a ditch for 12 or 15 miles along the Chatanika, which would divert water from a point near the junction of Faith and McManus creeks, a head of about 400 feet could be obtained. A daily flow of 100 second-feet under a 400-foot head would develop 3,640 horsepower on the turbines. This could easily be transmitted to the mining camps, where, by the use of pumps, water from the Chatanika could be furnished to the producing creeks along this river. This would require less than 50 miles of distributing ditch.

A similar enterprise, mentioned in the description of the Little Chena drainage basin (p. 107), would develop sufficient power for pumping water to Fairbanks Creek.

This method of utilizing the water supply would dispense with many miles of ditch construction and would not only supply the camp with water, but also with power for running the hoist, elevating the tailings, pumping water from mines, lighting the underground work, and, in some localities, running the dredger.

### STORAGE.

In this country, where for six months in the year the ground is frozen from surface to bed rock—10, 20, 30, and in many places more than 200 feet below—and the streams are closed by ice, it is perhaps more practical to use the daily flow of a stream during the open season than to attempt to conserve any excessive run-off; but continuous records may develop the fact that storage reservoirs are necessary from a commercial standpoint, notwithstanding the obvious difficulties connected with their construction and maintenance.

Computations have been made of the amounts of storage that would have been necessary to maintain discharges of 75, 100, and 125 second-feet in a ditch diverting water from Chatanika River near Faith Creek. These are given in the following table, together with the number of days of deficient flow for the different capacities:

*Storage table for Chatanika River near Faith Creek, 1907.*

| Capacity of ditch. | Days of deficient flow. | Net storage required. | |
|---|---|---|---|
| *Sec.-ft.* | | *Sec.-ft. for 1 day.* | *Acre-ft.* |
| 75 | 40 | 795 | 1,570 |
| 100 | 56 | 2,100 | 4,158 |
| 125 | 63 | 3,100 | 6,138 |

This table covers the period from June 16 to September 1. During this time there were days when the discharge of the streams exceeded the capacity of the proposed ditches. This excess would have been stored in the reservoirs. The periods of deficient flow for the different ditches occurred as follows: For a capacity of 75 second-feet, from June 20 to July 17 and from August 11 to 12; for a capacity of 100 second-feet, June 18 to August 1 and August 12 to 21; for a capacity of 125 second-feet, from June 15 to August 6 and August 9 to 24.

It would have been necessary to conserve the entire amount of flow for the larger ditch previous to June 15 and 90 per cent of the storage for the 100-second-feet ditch previous to June 15. After July 30 the daily discharge of the streams would have taken care of the smaller ditch.

For the satisfactory development of water supply for either ditch lines or power purposes it is necessary to have a thorough knowledge of the flow of the streams from which the projects are to receive their supply and an understanding of the conditions affecting that flow. The success of any such project is measured largely by the information which enables the engineer to design his work in accordance with the maximum efficiency of the available water supply, and this can be determined with greater accuracy by the aid of long-continued records.

In some of the older mining camps of Alaska the results of failure to investigate the water supply and the necessity for its use before constructing a ditch line can be seen in the almost dry ditch bottoms at times of greatest demand for water and the lack of productive ground on which to use the supply when it is obtainable.

If the work set forth in the foregoing pages aids in developing the water supply in the Fairbanks district and points out to the prospector and engineer the value of first investigating the water supply and its use before building a ditch, this report, in a measure, will have served its purpose.

# METEOROLOGICAL RECORDS.

By Fred F. Henshaw and C. C. Covert.

## INTRODUCTION.

The United States is divided by the Appalachian and Rocky Mountain systems into three distinct geographic provinces. Rainfall records show that the precipitation is greatest on the slopes toward the coast lines, and also that it is heaviest on the higher slope. Brooks [a] shows that similar geographic divisions are present in Alaska, except that the general direction is east and west, instead of north and south as in the States, the highest range lying to the south.

Abbe [b] in his report on climatic conditions in Alaska shows clearly that the heaviest precipitation occurs on the southern coastal slope. Abbe's tables also show a marked difference between the rainfall of the coast and that of the interior. The southern portion of Alaska is characterized by its dense forests, steeply graded but small drainage areas, and heavy precipitation. In contrast to these conditions the interior has larger drainage basins, more numerous flat and broad areas, less timber, and less precipitation. In Seward Peninsula the country is characterized by barren conditions, gradual slope to one minor mountain range, and a comparatively medium rainfall, with considerable local variation.

One of the important facts brought out by the stream-gaging work in Alaska during the last two years is the direct relation existing between rainfall and run-off during the open season. This is graphically illustrated by figs. 1 and 2 in this report.

It will be seen from a study of the foregoing pages that the maximum discharge of streams usually occurs in May and June, that the minimum flow comes in July and the early part of August, and that during the latter part of August and September the discharge fluctuates, but in the aggregate increases up to the freeze-up, which occurs in October. A study of the available rainfall records shows that this distribution of flow is the direct result of climatic conditions. The winter is a season of slight precipitation. This comes in the form of snow, which accumulates up to about the middle of April, when the increasing sunshine has its effect and the general break-up begins.

[a] Brooks, A. H., Geography and geology of Alaska; Prof. Paper U. S. Geol. Survey No. 45, 1906, Pl. II.
[b] Abbe, Cleveland, jr., Prof. Paper U. S. Geol. Survey No. 45, 1906, pp. 189–200.

The discharge resulting from the break-up reaches its maximum in May. April, June, and July are usually the months of least precipitation. After the high water caused by the spring break-up has disappeared, there is little additional supply to the streams, owing to the frozen condition of the ground and the slight rainfall. Consequently the streams rapidly reach a point of low discharge. The rainfall records also show that during August and September there is a gradual increase in the amount of precipitation. This, together with the effect of temperature on the frozen ground, is the primary cause of the increased flow of streams at this period.

All of this information has an important bearing on the development of the country. Mention has been made elsewhere in this report of the importance of an adequate water supply in the development of placer mines, but placer mining is not the only natural resource of Alaska which affords promising fields for development. Notwithstanding the fact that in the interior the ground is frozen the greater part of the year, during the summer, when it is thawed to a slight depth, the soil produces a luxuriant growth of vegetation, particularly in the lower Tanana basin. It is possible to raise many kinds of vegetables and small fruits, as well as hay and grain, and already agricultural pursuits are being followed more or less near the large towns. With the high prices for vegetables and general produce, the truck gardener in 1906 and 1907 found this occupation almost as lucrative as mining. It is obvious that in the agricultural development of any portion of this country it is important to know the length of the growing season, the amount of precipitation, and the number of sunshiny days which may be expected.

As meteorological records play so important a part in the development of Alaska, it is gratifying to note the number of places at which they are kept. The importance of the continuity of these records can not be too strongly impressed on the observers. For a number of years the Weather Bureau and the Signal Corps of the Army have kept records which cover most of the country in a general way.

During 1906 and 1907 the Geological Survey collected a considerable amount of climatological data in the Nome and Kougarok regions of Seward Peninsula and in the Fairbanks district. The daily records for these stations and the monthly summaries for all stations since 1902 are given in the following pages. All records up to 1902 are taken from Abbe's report, to which previous reference has been made.

## SEWARD PENINSULA.

When stream-gaging work was begun in Seward Peninsula in the spring of 1906, it was thought advisable to obtain records of rainfall at several points distributed so as to cover in a general way the whole of the peninsula. Four rain gages were installed, the stations selected

being Nome, on the southern coast; Salmon Lake, about 40 miles inland and south of Kigluaik Mountains; claim 15, Ophir Creek, near Council in the eastern portion of the peninsula; and Deering, on the coast of Kotzebue Sound to the north. No records were obtained from Deering, and therefore all the data procured here were for the area south of the mountains, where there are no striking differences in climate. In 1907 the scope of the observations was broadened, and an attempt was made to establish a line of rainfall stations from coast to coast of the peninsula across the Kigluaik Mountains. Additional rain gages were installed at Black Point, near the head of Nome River; at the forks of Grand Central River, in the heart of the mountains; and at Shelton and Taylor, north of the mountains. No records were obtained on the northern coast. The location of these stations is shown on Pls. IV, VII, and XII, and other information in regard to them is given in the following table:

*Seward Peninsula rainfall stations.*

| Station. | Letter on Pls. IV, VII, and XII. | Latitude. | Longitude. | Elevation. | | Observer. | Date established. |
|---|---|---|---|---|---|---|---|
| | | | | Above sea level. | Above ground. | | |
| | | | | *Feet.* | *Feet.* | | |
| Nome | A | 64° 30′ | 165° 24′ | 40 | 20 | Arthur Gibson | June 14, 1906 |
| Salmon Lake | B | 64° 54′ | 164° 56′ | 445 | 2 | J. P. Samuelson and M. Donworth. | June 26, 1906 |
| Ophir | C | 64° 59′ | 163° 39′ | 200 | 2 | C. Arnold | July 1, 1906 |
| Black Point | D | 64° 51′ | 165° 16′ | 575 | 2 | F. F. Miller | June 23, 1907 |
| Grand Central | E | 64° 58′ | 165° 14′ | 690 | 2 | Cornelus Edmunds | July 10, 1907 |
| Shelton | F | 65° 13′ | 164° 48′ | 60 | 2 | Lars Gunderson | July 12, 1907 |
| Taylor | G | 65° 42′ | 164° 48′ | 550 | 2 | A. E. Edgtvet | July 18, 1907 |

The records for 1907 show a striking difference between the Kigluaik region and the country south of the mountains. The totals for the three months July to September at Shelton and Taylor are only 2.51 and 2.79 inches, respectively. These are less than one-half the total at Nome, about one-third that at Black Point and Salmon Lake, and only one-sixth the amount at Grand Central. This deficiency is probably due to the fact that the heaviest rains are accompanied by southerly winds which loose most of their moisture by the time they have passed the mountains. The largest percentage of rain accompanied by winds from the south was 76 per cent at Black Point; the smallest, 35 per cent at Taylor. The whole region is subject to local showers, many of which are heavy in one valley and not felt in the next. The rain from a general storm is often very unequally distributed.

The following statement gives briefly the climatic conditions existing in this area during the years 1899–1907:

1899. July, four rainy days; August, fourteen rainy days; September, fourteen rainy days; recorded at Teller.

1900. June and July, warm and dry, tundra fires common; August to end of September, rain.

1901. June to August, inclusive, cold and foggy with some rain; September and October, usually clear and cold with one or two hard rains of a few days' duration.

1902. June, dry; July, ten rainy days; August, six rainy days; September, three rainy days; recorded at Teller.

1903. Summer warm; little rain, but considerable fog.

1904. June, dry; rainy days as follows: Ten in July, ten in August, ten in September; temperature moderate.

1905. Very wet and cold the whole season.

1906. Very warm and dry; tundra fires common; maximum temperature 85°.

1907. A heavy snowfall and a late spring; rainfall not excessive, but water supply of Nome region good on account of its even distribution throughout the season.

The records of rainfall, snowfall, temperature, and other weather elements observed in Seward Peninsula are given below:

*Monthly rainfall, in inches, in Seward Peninsula, 1906–7.*

| Station. | June. | July. | August. | September. | Total, June to August. | Total, June to September. | Total, July to September. |
|---|---|---|---|---|---|---|---|
| 1906. | | | | | | | |
| Nome | Trace. | 2.38 | 2.50 | 1.02 | 4.88 | 5.90 | 5.90 |
| Salmon Lake | Trace. | 4.92 | 3.33 | 3.26 | 8.25 | 11.51 | 11.51 |
| Ophir | Trace. | 3.57 | 1.91 | (a) | 5.48 | ..... | ..... |
| 1907. | | | | | | | |
| Nome | 1.31 | 2.08 | 2.68 | 1.41 | 6.07 | 7.48 | 6.17 |
| Black point | 2.62 | 1.94 | 2.85 | 3.26 | 7.41 | 10.67 | 8.05 |
| Salmon Lake | 2.31 | 1.79 | 3.65 | 2.26 | 7.75 | 10.01 | 7.70 |
| Grand Central | (a) | 3.61 | 7.19 | 5.06 | ..... | ..... | 15.86 |
| Shelton | (a) | .71 | 1.33 | .47 | ..... | ..... | 2.51 |
| Taylor | (a) | .66 | .96 | 1.17 | ..... | ..... | 2.79 |

[a] No record.

*Daily rainfall, in inches, at stations near Nome, 1906.*

| Day. | July. | | | August. | | | September. | |
|---|---|---|---|---|---|---|---|---|
| | Nome. | Salmon Lake. | Ophir. | Nome. | Salmon Lake. | Ophir. | Nome. | Salmon Lake. |
| 1 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.14 |
| 2 | ..... | ..... | ..... | ..... | ..... | Trace. | 0.04 | ..... |
| 3 | ..... | 0.12 | ..... | ..... | ..... | ..... | ..... | ..... |
| 4 | ..... | .35 | ..... | ..... | 0.17 | 0.01 | ..... | ..... |
| 5 | ..... | .35 | ..... | 0.07 | .07 | .05 | ..... | ..... |
| 6 | ..... | .10 | 0.02 | ..... | .23 | .03 | ..... | ..... |
| 7 | [a] 0.52 | .17 | .23 | [b] .41 | .28 | ..... | ..... | ..... |
| 8 | .37 | 2.32 | 1.30 | ..... | ..... | ..... | ..... | .01 |
| 9 | .92 | .31 | .19 | Trace. | .29 | .08 | ..... | ..... |
| 10 | .14 | .25 | ..... | ..... | ..... | .12 | ..... | ..... |
| 11 | ..... | ..... | .85 | ..... | ..... | .01 | ..... | ..... |
| 12 | .04 | ..... | .01 | ..... | .10 | ..... | ..... | ..... |
| 13 | ..... | ..... | .02 | ..... | ..... | ..... | .12 | ..... |
| 14 | ..... | .35 | .01 | ..... | ..... | ..... | .01 | .03 |
| 15 | ..... | ..... | .02 | ..... | ..... | ..... | ..... | ..... |
| 16 | ..... | ..... | .02 | ..... | ..... | ..... | ..... | ..... |
| 17 | ..... | ..... | ..... | ..... | .10 | ..... | .14 | .01 |
| 18 | ..... | ..... | .01 | ..... | ..... | ..... | .16 | .28 |
| 19 | ..... | ..... | ..... | ..... | ..... | .31 | .23 | 1.06 |
| 20 | ..... | ..... | ..... | ..... | .57 | .31 | .28 | .99 |
| 21 | ..... | .25 | .01 | .80 | ..... | ..... | .04 | .55 |
| 22 | ..... | ..... | .01 | ..... | ..... | ..... | ..... | .16 |
| 23 | .08 | ..... | .60 | .22 | .50 | .22 | ..... | .03 |
| 24 | .27 | .35 | .25 | ..... | ..... | ..... | ..... | ..... |
| 25 | .04 | ..... | .01 | .04 | .01 | .05 | ..... | ..... |
| 26 | ..... | ..... | ..... | .37 | .78 | .40 | ..... | ..... |
| 27 | ..... | ..... | .01 | .30 | .23 | .32 | ..... | ..... |
| 28 | ..... | ..... | ..... | .14 | ..... | ..... | ..... | ..... |
| 29 | ..... | ..... | ..... | .15 | ..... | ..... | ..... | ..... |
| 30 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 31 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 2.38 | 4.92 | 3.57 | 2.50 | 3.33 | 1.91 | 1.02 | 3.26 |

[a] Total, July 1–7. [b] Total, Aug. 6–7.

NOTE.—During June there was no measurable precipitation at any of the stations.

*Daily rainfall and snowfall, in inches, at Nome, 1906–7.*

| Day. | October. | November. | December. | | January. | | February. | | March. | | April. | May. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rain.[a] | Rain.[a] | Rain. | Snow. | Rain. | Snow. | Rain. | Snow. | Rain. | Snow. | Rain. | Rain. |
| 1 | | 0.20 | | | | | | | | | | |
| 2 | | .12 | | | 0.13 | 1.2 | | | | | | |
| 3 | | | | | | | | | 0.52 | 4.2 | | 0.05 |
| 4 | | | | | .40 | 3.6 | | | | | | .03 |
| 5 | 0.14 | | | | | | | | .13 | 1.1 | | .39 |
| 6 | | | | | .95 | 6.0 | | | | | | .08 |
| 7 | | | 0.17 | 2.0 | | | | | .36 | 3.0 | | .12 |
| 8 | | | | | | | | | | | | |
| 9 | .13 | | | | | | | | | | | |
| 10 | | | | | .23 | 1.6 | | | .87 | 7.5 | | |
| 11 | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | |
| 13 | | | | | .07 | .5 | | | | | | |
| 14 | .09 | | | | .26 | 5.3 | | | | | | .09 |
| 15 | | | | | .28 | 4.0 | | | | | | .04 |
| 16 | | | | | | | | | | | | |
| 17 | | | | | | | | | .57 | 5.5 | | |
| 18 | | | | | | | | | .09 | 1.0 | | |
| 19 | | | | | | | | | | | | |
| 20 | | | | | .32 | 3.0 | | | | | | |
| 21 | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | .04 |
| 24 | | | .74 | 5.5 | | | 0.56 | 4.5 | .75 | 5.7 | 0.03 | .04 |
| 25 | | | .24 | 2.8 | | | .30 | 3.0 | .08 | .8 | .07 | .24 |
| 26 | .23 | | .08 | 1.0 | | | .41 | 3.6 | | | | |
| 27 | .34 | | | Tr. | | | .04 | .5 | | | | |
| 28 | | | | | | | .15 | 2.3 | | | | |
| 29 | | | .38 | 5.0 | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 31 | | | .30 | 4.5 | | | | | | | | |
| | .93 | .32 | 1.91 | 20.8 | 2.64 | 25.2 | 1.46 | 13.9 | 3.37 | 28.8 | .10 | 1.12 |

[a] Most of the precipitation in October and November was in the form of snow; snowfall not measured.

*Daily rainfall, in inches, at stations in Seward Peninsula, 1907.*

| Day. | June. | | | July. | | | | | | August. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nome. | Black Point. | Salmon Lake. | Nome. | Black Point. | Salmon Lake. | Grand Central. | Shelton. | Taylor. | Nome. | Black Point. | Salmon Lake. |
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | 0.17 | |
| 3 | | | | | | | | | | | .02 | |
| 4 | | | | | | | | | | | .01 | |
| 5 | | | | 0.03 | 0.12 | | [a] 0.12 | | | | | |
| 6 | 0.05 | [a] 0.07 | | .48 | .35 | 0.54 | [a] .88 | | | | | |
| 7 | .08 | [a] .11 | | .30 | .13 | | [a] .14 | | | | | |
| 8 | | | | .01 | .14 | .10 | [a] .24 | | | | | |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | .10 | | | | | | |
| 11 | | | | .03 | .02 | .12 | [b] .12 | | | | | |
| 12 | | | | .02 | .05 | | [b] .16 | Tr. | | | .09 | |
| 13 | | | | .07 | .07 | .10 | [b] .07 | | | 0.19 | .04 | 0.40 |
| 14 | | | | .01 | .04 | .10 | [b] .13 | .01 | | .11 | .10 | |
| 15 | | | | | .02 | | [b] .11 | .01 | | .04 | .56 | |
| 16 | | [a] .26 | [c] 0.46 | .05 | .07 | | [b] .07 | .01 | | .38 | .50 | .39 |
| 17 | .08 | [a] .06 | | | | | | | | .07 | .15 | .65 |
| 18 | .31 | [a] .56 | .63 | .20 | .12 | | [b] .12 | | | .01 | .02 | .40 |
| 19 | .06 | [a] .21 | .32 | .06 | .04 | | [b] .04 | | | .05 | | |
| 20 | .21 | [a] .34 | .36 | .05 | .16 | .20 | [b] .40 | | .14 | .22 | .15 | .32 |
| 21 | | | | .04 | .28 | .26 | [b] .58 | .06 | Tr. | .06 | .06 | .17 |
| 22 | | | | | | | | | Tr. | | | |
| 23 | .02 | .02 | | .22 | .16 | | [b] .18 | .05 | .29 | .01 | | |
| 24 | .03 | .08 | | .47 | | .15 | [b] .17 | .53 | .08 | .11 | .22 | .10 |
| 25 | .20 | .22 | .20 | .04 | | | | .04 | | .02 | .03 | |
| 26 | .27 | .69 | .34 | | | | | | Tr. | 1.02 | .30 | .65 |
| 27 | | | | | | | | | | .20 | .22 | .15 |
| 28 | | | | | | | | | | .07 | .06 | |
| 29 | | | | | | | | | | .05 | .05 | .30 |
| 30 | | | | | .17 | | .08 | | .12 | .07 | .10 | .12 |
| 31 | | | | | | .12 | | | .03 | | | |
| | 1.31 | 2.62 | 2.31 | 2.08 | 1.94 | 1.79 | 3.61 | .71 | .66 | 2.68 | 2.85 | 3.65 |

[a] Estimated by comparison of stations.
[b] July 10 to 16 total was 0.66; July 17 to 25 total was 1.49; these were distributed in proportion to rainfall at Black Point and Salmon Lake.
[c] Total June 1 to 16.

*Daily rainfall, in inches, at stations in Seward Peninsula, 1907*—Continued.

| Day. | August—Continued. | | | September. | | | | | | October. | November. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grand Central. | Shelton. | Taylor. | Nome. | Black Point. | Salmon Lake. | Grand Central. | Shelton. | Taylor. | Nome. | Nome. |
| 1 | | | | | 0.10 | | 0.05 | 0.01 | 0.03 | | 0.04 |
| 2 | 0.20 | 0.01 | | | | | | | .01 | | |
| 3 | .09 | .15 | | 0.14 | .06 | | .04 | | Tr. | | |
| 4 | .05 | .05 | 0.09 | .02 | .16 | 0.34 | 32 | .02 | .33 | | |
| 5 | | | | | | | .04 | | Tr | | .01 |
| 6 | | | | .10 | | .10 | | .01 | .06 | | |
| 7 | | | | | .14 | | .07 | | | 0.02 | |
| 8 | | | | .07 | .20 | .10 | .11 | .01 | .01 | | |
| 9 | | | | .17 | .36 | .45 | 1.36 | | .27 | | |
| 10 | | | | .61 | 1.40 | .35 | 1.96 | .20 | .28 | | |
| 11 | .02 | | Tr. | .08 | .33 | .60 | .66 | .12 | | | |
| 12 | .02 | | Tr. | | .07 | .17 | .03 | | .01 | | |
| 13 | .08 | .01 | .03 | | | | | | | | |
| 14 | .10 | .10 | .07 | .04 | .07 | | .05 | | | | |
| 15 | | .03 | Tr. | .06 | .22 | | .08 | | .17 | | |
| 16 | .70 | 09 | Tr. | | | | | | Tr | | |
| 17 | .83 | .11 | .15 | | | | | | | | 01 |
| 18 | .40 | .13 | .13 | | | | | | Tr. | | |
| 19 | .02 | .05 | | | | | | | | | |
| 20 | | .07 | | | | | | | Tr. | | |
| 21 | .48 | .03 | 22 | .03 | .04 | | .03 | .06 | | | |
| 22 | .12 | | .01 | | | | | | | .04 | |
| 23 | .02 | | .01 | | | | | | | | |
| 24 | .20 | .12 | .07 | | | | | Tr. | | .05 | |
| 25 | .14 | .03 | .02 | .02 | .05 | | a.05 | | | .05 | |
| 26 | .50 | .20 | .08 | | 06 | .15 | a.21 | | | | |
| 27 | .20 | .07 | .03 | .06 | | | | | | | |
| 28 | .07 | | | | | | | .04 | | | |
| 29 | 1.90 | .08 | Tr. | .01 | | | | | | | |
| 30 | 1.03 | | .05 | | | | | | | | |
| 31 | .02 | | Tr. | | | | | | | | |
| | 7.19 | 1.33 | .96 | 1.41 | 3.26 | 2.26 | 5.06 | .47 | 1.17 | .16 | .06 |

*Daily mean temperature (°F.) at Nome, 1906–7.*

| Day. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | June. | July | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 23.5 | 8.5 | 9.5 | − 0.5 | 37.5 | 41.0 | 45.5 | 54.0 | 40.5 | 40.0 | 11.5 |
| 2 | 2.0 | 29.5 | − 1.0 | 1.5 | 15.0 | 37.0 | 45.0 | 48.5 | 54.5 | 41.0 | 33.0 | 13.0 |
| 3 | 2.0 | 14.0 | − 5.5 | 20.5 | 13.5 | 40.0 | 42.5 | 44.5 | 54.5 | 37.0 | 25.5 | 3.5 |
| 4 | −2.0 | 25.5 | − 2.0 | 24.0 | 12.5 | 37.5 | 44.0 | 46.0 | 54.0 | 41.5 | 26.5 | 6.0 |
| 5 | −2.0 | 15.5 | −11.5 | 23.0 | 13.0 | 35.5 | 41.0 | 49.0 | 48.0 | 42.0 | 25.5 | 8.5 |
| 6 | 5.0 | 25.0 | −13.5 | 20.5 | − 0.5 | 33.5 | 46.0 | 50.0 | 44.0 | 38.5 | 26.0 | 6.0 |
| 7 | 1.0 | 24.5 | − 1.5 | 28.5 | .0 | 38.5 | 41.0 | 46.5 | 52.0 | 41.0 | 32.5 | 2.5 |
| 8 | − .5 | 11.5 | −10.0 | 26.0 | − 2.0 | 43.0 | 38.0 | 46.0 | 58.0 | 44.5 | 33.0 | − 3.0 |
| 9 | −5.0 | − 8.0 | −15.0 | 25.5 | 10.0 | 43.5 | 52.0 | 51.5 | 50.5 | 46.5 | 24.0 | − 0.5 |
| 10 | − .5 | 4.0 | −13.0 | 29.5 | 3.0 | 39.5 | 50.5 | 56.5 | 50.0 | 47.5 | 22.0 | 8.5 |
| 11 | −3.0 | 20.5 | −14.0 | 29.0 | 15.0 | 26.0 | 48.0 | 57.5 | 54.5 | 46.5 | 26.0 | 18.5 |
| 12 | 6.0 | 25.0 | −25.0 | 21.5 | 26.0 | 20.5 | 51.0 | 49.0 | 57.5 | 42.0 | 26.0 | 19.0 |
| 13 | 3.5 | 24.0 | −20.5 | 7.0 | 33.5 | 22.5 | 57.5 | 49.5 | 59.5 | 39.5 | 19.0 | 29.5 |
| 14 | 3.0 | 18.5 | −19.5 | − 4.5 | 29.0 | 28.0 | 50.5 | 51.0 | 56.0 | 40.0 | 21.0 | 28.0 |
| 15 | 17.0 | 16.0 | −27.5 | − 5.0 | 17.5 | 26.0 | 42.0 | 52.0 | 53.5 | 45.5 | 23.0 | 33.5 |
| 16 | 23.0 | − .5 | −22.0 | − 4.0 | 13.5 | 25.5 | 42.5 | 51.5 | 50.5 | 38.0 | 23.5 | 23.0 |
| 17 | 16.5 | − 7.5 | −18.5 | 15.0 | 5.5 | 30.0 | 43.5 | 49.0 | 48.5 | 39.0 | 26.5 | 20.0 |
| 18 | 8.5 | −20.0 | −22.5 | 18.5 | 7.0 | 31.0 | 45.0 | 46.5 | 51.0 | 36.0 | 23.0 | 19.5 |
| 19 | 3.5 | − 6.0 | −15.5 | − 5.0 | 8.0 | 31.0 | 40.0 | 46.5 | 48.5 | 36.5 | 27.0 | 13.5 |
| 20 | − .5 | 11.5 | −22.5 | − 9.0 | 18.5 | 32.0 | 42.0 | 49.5 | 54.0 | 35.5 | 20.0 | 9.5 |
| 21 | −4.0 | 11.5 | −18.0 | −15.5 | 24.0 | 36.0 | 45.0 | 49.0 | 53.0 | 43.5 | 27.0 | 14.0 |
| 22 | 2.0 | 1.5 | − 6.0 | −17.0 | 26.0 | 37.5 | 43.5 | 48.5 | 48.5 | 38.0 | 27.0 | 6.5 |
| 23 | −1.0 | 23.0 | − 1.5 | −13.5 | 33.0 | 43.5 | 52.5 | 54.0 | 42.0 | 36.0 | 25.0 | 2.5 |
| 24 | 10.0 | 21.5 | 12.5 | 16.0 | 33.0 | 39.0 | 52.5 | 53.0 | 38.5 | 37.5 | 29.0 | 4.5 |
| 25 | 20.0 | 23.5 | 25.0 | 10.0 | 35.5 | 36.5 | 49.0 | 51.0 | 40.0 | 39.0 | 34.0 | − 3.0 |
| 26 | 18.0 | 14.0 | 24.5 | − 8.0 | 37.5 | 34.0 | 47.0 | 52.0 | 45.5 | 45.5 | 29.5 | − 4.5 |
| 27 | 8.5 | 13.5 | 17.5 | −10.0 | 37.0 | 29.5 | 42.5 | 47.0 | 45.5 | 42.0 | 21.5 | − 4.5 |
| 28 | 7.0 | 10.5 | 6.5 | −14.5 | 34.0 | 34.5 | 41.5 | 46.0 | 44.0 | 45.0 | 19.5 | 1.5 |
| 29 | 19.0 | 4.5 | | −18.5 | 36.0 | 36.0 | 44.0 | 51.5 | 47.0 | 45.0 | 9.5 | .5 |
| 30 | 20.0 | .5 | | −19.5 | 36.0 | 40.5 | 45.5 | 56.0 | 45.5 | 42.0 | 7.5 | − 3.5 |
| 31 | 25.5 | .0 | | − 6.5 | | 38.5 | | 57.5 | 41.0 | | 7.0 | |
| Mean | 6.8 | 11.9 | − 7.6 | 5.6 | 19.0 | 34.3 | 45.5 | 50.0 | 49.8 | 41.1 | 24.5 | 9.5 |

*Daily barometer, in inches, at Nome, 1906–7.*

| Day. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ..... | 29.97 | 30.64 | 30.04 | 30.12 | 30.10 | 29.92 | 30.00 | 29.84 | 29.83 | 29.40 | 29.93 |
| 2 | 30.85 | 29.68 | 30.64 | 29.67 | 30.22 | 30.25 | 29.83 | 30.00 | 29.68 | 29.93 | 29.44 | 29.75 |
| 3 | 30.89 | 28.95 | 30.58 | 29.46 | 29.77 | 30.18 | 29.75 | 29.85 | 29.74 | 29.90 | 29.45 | 29.74 |
| 4 | 31.00 | 29.31 | 30.50 | 29.66 | 29.60 | 29.77 | 29.75 | 29.71 | 29.88 | 29.90 | 29.55 | 29.76 |
| 5 | 30.78 | 29.97 | 30.24 | 29.38 | 29.70 | 29.75 | 29.87 | 29.71 | 30.04 | 29.95 | 29.76 | 29.63 |
| 6 | 30.43 | 29.12 | 30.05 | 30.04 | 29.82 | 30.00 | 29.81 | 29.66 | 30.14 | 29.88 | 29.77 | 29.42 |
| 7 | 30.40 | 29.89 | 29.96 | 29.69 | 29.93 | 29.87 | 29.85 | 29.94 | 29.95 | 29.77 | 29.67 | 29.78 |
| 8 | 30.79 | 30.43 | 30.23 | 30.21 | 29.86 | 29.80 | 29.82 | 30.02 | 30.00 | 30.17 | 29.69 | 30.03 |
| 9 | 30.43 | 31.08 | 30.22 | 30.26 | 29.85 | 29.78 | 29.82 | 29.76 | 29.97 | 30.29 | 30.04 | 29.87 |
| 10 | 30.36 | 30.81 | 30.03 | 29.59 | 30.05 | 29.68 | 29.73 | 29.85 | 29.85 | 29.95 | 29.95 | 29.98 |
| 11 | 30.33 | 30.60 | 29.90 | 29.87 | 29.93 | 29.70 | 29.75 | 29.79 | 29.86 | 29.95 | 29.92 | 30.32 |
| 12 | 29.99 | 30.47 | 29.79 | 30.15 | 29.75 | 29.72 | 29.86 | 30.21 | 29.84 | 30.44 | 30.05 | 29.98 |
| 13 | 30.03 | 30.40 | 29.49 | 30.65 | 29.75 | 29.83 | 30.00 | 30.18 | 29.72 | 30.32 | 30.15 | 29.66 |
| 14 | 30.24 | 30.37 | 29.60 | 30.50 | 29.85 | 29.82 | 29.86 | 30.10 | 29.89 | 30.09 | 30.20 | 29.57 |
| 15 | 30.12 | 30.20 | 29.79 | 30.35 | 30.03 | 30.16 | 29.88 | 29.80 | 29.98 | 30.11 | 30.16 | 29.40 |
| 16 | 29.75 | 30.28 | 30.20 | 30.14 | 30.27 | 30.40 | 29.99 | 29.90 | 29.74 | 30.10 | 30.06 | 29.56 |
| 17 | 29.73 | 30.51 | 30.18 | 29.14 | 30.48 | 30.51 | 29.93 | 29.94 | 29.68 | 29.97 | 29.89 | 29.30 |
| 18 | 29.86 | 30.32 | 30.39 | 29.46 | 30.36 | 30.50 | 29.66 | 29.90 | 29.76 | 29.90 | 29.77 | 29.31 |
| 19 | 30.10 | 29.98 | 30.37 | 29.96 | 30.00 | 30.37 | 30.12 | 29.91 | 29.66 | 29.78 | 29.35 | 29.48 |
| 20 | 30.35 | 29 26 | 30.43 | 29.80 | 30.06 | 30.32 | 29.96 | 29.55 | 29.22 | 29.20 | 29.20 | 29.34 |
| 21 | 30.40 | 29.97 | 30.27 | 30.13 | 30.42 | 30.12 | 29.82 | 29.67 | 29.32 | 29.15 | 29.27 | 29.35 |
| 22 | 30.27 | 29.84 | 29.95 | 30.54 | 30.33 | 30.08 | 29.86 | 29.80 | 29.58 | 29.68 | 29.68 | 29.27 |
| 23 | 29.57 | 30.56 | 29.92 | 30.10 | 30.17 | 30.00 | 29.64 | 29.83 | 29.77 | 29.94 | 29.74 | 29.45 |
| 24 | 29.38 | 30.73 | 29.29 | 29.10 | 29.96 | 29.93 | 29.90 | 29.83 | 29.66 | 29.93 | 29.44 | 29.64 |
| 25 | 29.16 | 30.78 | 29.07 | 29.74 | 29.91 | 30.00 | 29.83 | 29.90 | 29.79 | 29.49 | 29.44 | 29.68 |
| 26 | 29.77 | 30.74 | 29.21 | 30.39 | 29.73 | 30.08 | 30.00 | 29.90 | 29.67 | 29.55 | 29.48 | 29.78 |
| 27 | 30.24 | 30.72 | 29.58 | 30.44 | 29.95 | 30.10 | 30.28 | 29.87 | 29.81 | 29.42 | 29.76 | 29.60 |
| 28 | 30.24 | 30.72 | 30.02 | 30.66 | 30.06 | 30.20 | 30.29 | 29.96 | 29.64 | 29.28 | 29.78 | 29.42 |
| 29 | 30.04 | 30.61 | ..... | 30.72 | 30.28 | 30.11 | 30.22 | 30.00 | 29.70 | 29.56 | 29.77 | 29.75 |
| 30 | 29.87 | 30.48 | ..... | 30.32 | 30.00 | 29.91 | 30.18 | 29.96 | 29.23 | 29.70 | 30.00 | 29.87 |
| 31 | 29.84 | 30.62 | ..... | 30.26 | ..... | 29.80 | ..... | 29.75 | 29.59 | ..... | 30.15 | ..... |
| Mean | 30.17 | 30.24 | 30.02 | 30.01 | 30.01 | 30.03 | 29.91 | 29.88 | 29.75 | 29.64 | 29.74 | 29.65 |

*Summary of meteorological observations at Nome, December, 1906, to November, 1907.*

| | | |
|---|---|---|
| Total precipitation, rain, and melted snow | inches.. | 18.30 |
| Total snowfall | do.... | 91.9 |
| Maximum temperature | ° F.. | 69 |
| Minimum temperature | ° F.. | −32 |
| Mean daily maximum temperature | ° F.. | 30.7 |
| Mean daily minimum temperature | ° F.. | 17.7 |
| Mean of means of maximum and minimum temperature | ° F.. | 24.2 |
| Mean barometer | inches.. | 29.92 |
| Number of clear days | | 152 |
| Number of partly cloudy days | | 50 |
| Number of cloudy days | | 163 |

## FAIRBANKS DISTRICT.

In connection with the stream-flow investigations begun in the Fairbanks district in 1907, it was considered advisable to establish a few rainfall stations at different places in the territory covered. Four rain gages were installed at the places listed in the following table. All records are kept by voluntary observers.

*Rainfall stations near Fairbanks.*

| Station. | Letter on Pls. IX and XII. | Latitude. | Longitude. | Elevation. Above sea level.[a] | Elevation. Above ground. | Observer. | Date established. |
|---|---|---|---|---|---|---|---|
| | | | | *Feet.* | *Feet.* | | |
| Summit Road House. | G | 65° 02′ | 147° 26′ | 2,310 | 3 | Mrs. Annie M. Walsh | July 3. |
| Cleary | H | 65° 05′ | 147° 26′ | 1,000 | 4 | Charles Sinclair | June 25. |
| Poker Creek | K | 65° 08′ | 147° 28′ | 750 | 5 | G. M. Sabean | Aug. 3. |
| Faith Creek | L | 65° 17′ | 146° 23′ | 1,400 | 4 | M. T. Kerrick | July 1. |

[a] Approximate.

The records kept at these stations, together with those being obtained by the United States Weather Bureau at Fairbanks, Central, and Circle, give a general idea of the rainfall distribution from Fairbanks on the Tanana to Circle on the Yukon, 150 miles to the northwest.

*Mean monthly precipitation at stations in Yukon-Tanana region, 1902–1907.*

| Station. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. | Length of record. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | *Yrs.* | *Mos.* |
| Central | 0.80 | 0.24 | 1.31 | 0.70 | 0.73 | 3.56 | 3.11 | 1.85 | 0.52 | 0.70 | 0.80 | 0.35 | 14.67 | 1 | 7 |
| Circle | 1.05 | .29 | .52 | .67 | .83 | .54 | 1.77 | 2.33 | 1.69 | 1.15 | .30 | .51 | 11.65 | 1 | 22 |
| Fairbanks | 1.99 | .58 | .93 | .11 | .36 | 1.26 | 2.16 | 1.98 | 1.56 | 1.37 | .92 | .88 | 14.10 | 1 | 18 |
| Fort Egbart | 1.01 | .39 | 1.37 | .18 | .66 | 1.23 | 1.98 | 1.73 | 1.95 | 1.93 | .72 | .38 | 13.53 | | 37 |
| Fort Gibbon | .54 | .49 | .46 | .10 | .50 | .74 | 2.80 | 3.04 | 1.05 | .85 | .52 | .50 | 11.59 | 1 | 33 |
| Kechumstuk | .46 | .11 | .12 | .22 | 1.24 | 1.51 | 1.87 | 1.77 | 1.20 | .62 | .22 | .21 | 9.55 | 2 | 18 |
| North Fork | .70 | .39 | .18 | .40 | 1.66 | 2.33 | 2.13 | 2.04 | 1.52 | .42 | .52 | .29 | 12.58 | 1 | 13 |
| Rampart | .90 | .26 | .67 | .03 | .42 | 1.04 | 2.04 | 2.66 | 1.60 | .82 | 1.19 | .33 | 11.96 | 1 | 17 |
| Dawson | 1.01 | .67 | .46 | .54 | .97 | .86 | 1.85 | 1.77 | 1.82 | 1.60 | 1.12 | 1.10 | 13.77 | 5 | 18 |

NOTE.—Values for the different months are averages of all observations for that month. In the column headed "Year" is given the total of these averages. Amounts given for the winter months, October to March, represent melted snow, and as a rule are taken as one-tenth of the snowfall.

Purington[a] publishes a summary of the rainfall data previous to 1903 as compiled by Cleveland Abbe, jr. These tables show not only the marked variation in rainfall along the coast, but the variations between the rainfall of the coast and that of the interior.

A record for thirteen years and eleven months at Juneau shows a yearly average of 93.1 inches, and one for fifty-two months at Eagle gives an average of 11.4 inches. A similar table compiled from records obtained subsequent to 1902, at stations in the interior, gives a range from 9.55 inches at Kechumstuk to 14.67 inches at Central. This table also shows that the heaviest precipitation occurs during the period from June to September, inclusive, and that the months of April and May are usually months of least precipitation. For the source of the data in this table see pages 142 to 149, inclusive, in this report.

The following tables show the daily and monthly rainfall at stations near Fairbanks:

[a] Purington, C. W., Methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905, page 48.

*Daily rainfall, in inches, at stations near Fairbanks, 1907.*

| Day. | January. | February. | March. | April. | May. | June. | | July. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fairbanks. | | | | | Fairbanks. | Cleary. | Fairbanks. | Summit Road House. | Cleary. | Faith Creek. |
| 1 | 0.05 | | | | | | | | | | |
| 2 | .22 | | 0.05 | | | | | | | | 0.02 |
| 3 | .16 | | | | | | | 0.04 | | 0.09 | |
| 4 | .35 | | .04 | | | | | | | | |
| 5 | .35 | 0.03 | | | | 0.15 | | | | | .04 |
| 6 | .04 | | | | | .09 | | | 0.30 | | |
| 7 | | | | | | .11 | | .35 | .06 | .30 | .14 |
| 8 | .36 | | | | | .07 | | .01 | | .09 | |
| 9 | .75 | | .04 | | 0.15 | | | | | | |
| 10 | .20 | | | | | .15 | | | .50 | .47 | .03 |
| 11 | | .16 | .17 | | | .05 | | .02 | .12 | .09 | .14 |
| 12 | | .04 | .40 | | | | | .05 | .22 | .32 | |
| 13 | | .07 | .17 | | .06 | | | | | | .03 |
| 14 | (a) | .17 | .05 | | | | | | .30 | | .05 |
| 15 | .20 | .21 | | 0.03 | | .02 | | .01 | .05 | .19 | .28 |
| 16 | .30 | .07 | | | | .18 | | .19 | .24 | .20 | .11 |
| 17 | .05 | .03 | | | | .10 | | | .03 | .01 | .01 |
| 18 | | | .80 | | | .02 | | .09 | .24 | .15 | .35 |
| 19 | | | .40 | | | | | | .13 | | |
| 20 | | | .10 | | | | | .14 | | | .13 |
| 21 | .02 | | | | | | | | | | |
| 22 | | | | | | | | .01 | | | |
| 23 | .20 | | | | | | | | | | |
| 24 | .05 | | | | | | | .25 | .22 | .27 | .23 |
| 25 | | | .20 | | | | | .18 | .15 | | |
| 26 | | | | | | | | .05 | .02 | .12 | .31 |
| 27 | | | | | | | 0.01 | | | .07 | |
| 28 | | .08 | | | | .23 | .41 | | | | |
| 29 | | | | | .13 | .30 | .42 | | .13 | .06 | |
| 30 | | | | | .01 | | | .12 | | .12 | |
| 31 | | | | | | | | | | | |
| Total. | b 3.30 | b .86 | b 2.42 | b .03 | .35 | 1.47 | c .84 | 1.51 | 2.71 | 2.55 | 1.87 |
| Snowfall... | 33.0 | 8.6 | 24.2 | .30 | | | | | | | |

| Day. | August. | | | | | September. | | October. | | November. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fairbanks. | Summit Road House. | Cleary. | Poker Creek. | Faith Creek. | Fairbanks. | Cleary. | Poker Creek. | Fairbanks. | Poker Creek. | Poker Creek. |
| 1 | 0.72 | 1.27 | 1.17 | | 0.49 | | | | 0.02 | | |
| 2 | .01 | .06 | .12 | | .19 | | | Tr. | | | |
| 3 | | | | | | | | | | | |
| 4 | | | .09 | | .20 | 0.18 | 0.08 | 0.10 | Tr. | Tr. | 0.08 |
| 5 | | | | | .03 | .03 | .14 | | Tr. | 0.05 | |
| 6 | .13 | .27 | .04 | 0.05 | .11 | | | | .10 | .30 | |
| 7 | | .07 | .22 | .24 | .15 | | .12 | .01 | .20 | .10 | |
| 8 | .01 | .42 | | | .15 | .18 | .11 | .02 | .05 | | |
| 9 | | .11 | .46 | .33 | .10 | .02 | .22 | .01 | .09 | .17 | .10 |
| 10 | .25 | | .08 | .05 | .02 | .05 | | Tr. | .23 | .30 | |
| 11 | | | | | | .23 | | .63 | .50 | .20 | .03 |
| 12 | | | | | | .71 | .21 | .88 | .25 | .10 | |
| 13 | | | | | .01 | | .80 | | | | |
| 14 | | | | | | | | | .03 | | |
| 15 | .09 | | | | .07 | .22 | .85 | .70 | | Tr. | |
| 16 | | | | .01 | .04 | .27 | | .10 | | | |
| 17 | | .09 | | .01 | | | | | | | |
| 18 | .12 | | .05 | .07 | .01 | | | | | | |
| 19 | | | | | | | | | .20 | .13 | |
| 20 | | | | | | .15 | .15 | .40 | | | |
| 21 | | .19 | | .13 | | .15 | | .13 | | | |
| 22 | .05 | .04 | .10 | .02 | .13 | .16 | .52 | .27 | | | |
| 23 | | .20 | .11 | .13 | | .37 | .23 | .15 | | | |
| 24 | .18 | .13 | .09 | .04 | .15 | .01 | | | | | |
| 25 | .12 | .03 | .13 | .15 | .36 | | | | | | |
| 26 | | | | | .03 | | | | | | |
| 27 | | | | | | | | | | | |
| 28 | | .26 | | .02 | .09 | | | | .30 | .20 | |
| 29 | .13 | .13 | .22 | .15 | .54 | .35 | | .30 | .47 | .15 | .04 |
| 30 | | | | | .13 | .50 | .39 | | | | |
| 31 | | | | | | | | | | | |
| Total. | 1.81 | 3.27 | 2.88 | 1.40 | 3.00 | 3.58 | 3.82 | 3.70 | b 2.44 | 1.70 | .25 |
| Snowfall... | | | | | | | | | 24.4 | 24.0 | 3.30 |

a Drifting. b Taken as 10 per cent of the snowfall. c June 25 to 30.

## SUMMARY OF RECORDS SINCE 1902.

All meteorological records obtained at stations in Alaska up to 1902 have been compiled by Abbe.[a] The following tables complete the record of precipitation to 1907, inclusive. The values for 1903 to 1905 for Weather Bureau stations have been taken from the annual report of the Chief of the Weather Bureau. Those for 1906 and 1907 were obtained from the original records through the courtesy of the Bureau officials. The snowfall is given only for 1906 and 1907. For these years the amount of rainfall and melted snow is given in the first line and the snowfall in the second line.

Most of the amounts given for the winter season in the previous years represent melted snow, and many of them have been taken as one-tenth of the observed snowfall. The water equivalent of snowfall varies considerably, and in general is probably somewhat less than this proportion in Alaska. In many parts of Alaska the snowfall is accompanied by wind and piles up in the form of drifts in sheltered places. This renders the accurate measurement of the quantity of snow very difficult, and many of these records can therefore be regarded as only approximate. The locations of all rainfall stations are given on Pl. XII.

*Summary of records of precipitation at stations in Alaska.*[b]

D. BLACK POINT.

[Latitude, 64° 51′; longitude, 165° 16′.]

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1907 | | | | | | 2.62 | 1.94 | 2.85 | 3.26 | | | | |

1. CENTRAL.

[Latitude, 65° 33′; longitude, 145° 49′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | 0.56 | 0.06 | 0.05 | 0.47 | 0.86 | 4.91 | 4.82 | 1.85 | 0.52 | 0.70 | 0.80 | 0.35 | 15.95 |
| | 6.1 | 1.0 | 1.4 | 4.7 | 2.0 | | | | | 7.0 | 8.0 | 4.0 | 34.2 |
| 1907 | 1.04 | .42 | 2.57 | .93 | .57 | 2.21 | 1.40 | | | | | | |
| | 10.0 | 4.0 | 24.0 | 8.0 | 1.5 | | | | | | | | |

H. CLEARY.

[Latitude, 65° 05′; longitude, 147° 26′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1907 | | | | | | | 2.55 | 2.88 | 3.82 | | | | |

2. CHISTOCHINA.

[Latitude, 62° 36′; longitude, 144° 44′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904 | | | | | | | | 0.40 | 2.01 | | | 0.20 | |
| 1905 | 0.05 | 0.02 | 0.08 | 0.00 | 0.48 | 0.90 | 3.19 | 3.20 | 3.11 | 1.68 | 0.03 | .75 | 13.49 |
| 1906 | .26 | .60 | .30 | Tr. | .00 | .81 | 1.78 | 1.48 | | | .50 | 1.80 | |
| | 2.5 | 6.0 | 3.0 | | | | | | | 1.0 | 5.0 | 18.0 | 35.5 |
| 1907 | 2.80 | .20 | .80 | | Tr. | 1.50 | 2.82 | 2.21 | 2.07 | 1.34 | | | |
| | 28.0 | 2.0 | 8.0 | | | | | | 5.0 | 6.0 | | | |

[a] Abbe, Cleveland, jr., Prof. Paper U. S. Geol. Survey No. 45, 1906, pp. 189–200.
[b] Numbers and letters refer to Pl. XII.

MAP OF ALASKA SHOWING LOCATION OF RAINFALL STATIONS

*Summary of records of precipitation at stations in Alaska*—Continued.

3. CIRCLE.

[Latitude, 65° 50′; longitude, 144° 4′.]

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | | | | | | | | | | | | 0.75 | |
| | | | | | | | | | | | | 9.5 | |
| 1907 | 1.02 | 0.57 | 0.28 | 0.15 | 0.29 | | 1.36 | 2.79 | 1.73 | | | .63 | |
| | 8.5 | 7.8 | 3.25 | | | | | | | | | 8.2 | |

4. COAL HARBOR, UNGA ISLAND.

[Latitude, 55° 20′; longitude, 160° 38′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 3.90 | 7.32 | 1.90 | 2.26 | 2.77 | 2.05 | 3.66 | 3.64 | 5.29 | 2.52 | 2.52 | 4.69 | 42.52 |
| 1904 | 2.00 | 0.12 | 0.66 | 1.89 | 1.83 | 1.23 | 4.22 | 4.17 | 3.73 | 2.07 | 2.82 | 2.00 | 26.74 |
| 1905 | 0.17 | 9.05 | 1.20 | 18.92 | 6.76 | 4.44 | 1.75 | 2.20 | 2.95 | 3.03 | 9.25 | 4.64 | 64.36 |
| 1906 | 2.33 | 5.43 | 6.46 | | 3.27 | 1.01 | 3.18 | 4.28 | 3.42 | 4.44 | 3.52 | 2.87 | |
| | 5.8 | 1.9 | 4.2 | Tr. | Tr. | | | | | | 7.3 | 2.25 | |
| 1907 | 5.65 | 0.20 | 1.43 | 7.99 | 4.59 | 1.88 | 4.71 | 4.90 | 5.84 | 5.83 | | | |
| | 3.5 | 1.2 | Tr. | 12.75 | | | | | | Tr. | | | |

5. COPPER CENTER.

[Latitude, 61° 58′; longitude, 145° 20′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 0.05 | 0.05 | 0.40 | Tr. | 0.60 | 1.38 | 0.99 | 1.16 | 1.34 | 1.71 | 0.20 | 0.75 | 8.63 |
| 1904 | .67 | .22 | Tr. | 0.24 | .92 | 1.11 | 1.80 | 2.09 | .73 | .48 | .36 | .68 | 9.30 |
| 1905 | .29 | 1.01 | .20 | Tr. | .48 | .50 | 1.35 | .72 | 1.94 | .97 | .94 | .97 | 9.37 |
| 1906 | 1.14 | .19 | .69 | .36 | .43 | 1.19 | 2.14 | .69 | .37 | .84 | .99 | .35 | 9.38 |
| | 17.2 | 2.8 | 9.2 | 3.0 | Tr. | | | | | | 8.5 | 6.0 | 46.7 |
| 1907 | | .60 | .30 | | .36 | 1.14 | .97 | .71 | .25 | 1.35 | .80 | .35 | |
| | | 6.6 | 3.0 | | | | | | | 11.5 | 8.0 | 3.5 | |

6. FAIRBANKS.

[Latitude, 64° 50′; longitude, 147° 44′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904 | | | | | | | | | | | 1.10 | 2.00 | |
| 1905 | 0.92 | 0.50 | 0.05 | 0.20 | | | | 2.63 | 0.86 | | 1.20 | 0.60 | |
| | 9.1 | 5.0 | .5 | 2.0 | | | | | | | 12.0 | 5.1 | |
| 1906 | 1.75 | .37 | .33 | .10 | 0.36 | 1.05 | 2.82 | 1.50 | .25 | .30 | .65 | 1.15 | 10.63 |
| | 17.5 | 3.7 | 3.3 | 1.0 | | | | | | 0.6 | 6.5 | 11.5 | 45.1 |
| 1907 | 3.30 | .86 | 2.42 | .03 | .35 | 1.47 | 1.51 | 1.81 | 3.58 | 2.44 | .35 | .59 | 18.71 |
| | 33.0 | 8.6 | 24.2 | .30 | | | | | | 24.4 | 3.5 | 5.9 | 99.9 |

L. FAITH CREEK.

[Latitude, 65° 17′; longitude, 146° 23′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1907 | | | | | | | 1.87 | 3.00 | 2.97 | | | | |

7. FORT EGBERT.

[Latitude, 64° 45′; longitude, 141° 10′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 0.58 | 0.81 | 0.54 | 0.12 | 1.38 | 0.57 | 2.40 | 0.97 | 2.97 | | | | |
| 1905 | | | | | .33 | 1.95 | 1.52 | 2.72 | 3.38 | 2.96 | 0.93 | 0.68 | |
| 1906 | | .14 | 2.19 | .00 | .54 | .51 | 2.54 | 1.28 | .01 | 1.71 | .51 | .07 | |
| | | 1.0 | 11.0 | | | | | | | 4.6 | 8.5 | 1.0 | |
| 1907 | 1.45 | .21 | | .25 | .40 | 1.89 | 1.48 | 1.98 | 1.45 | 1.12 | .40 | | |
| | 2.0 | 2.0 | | .15 | .55 | | | | | 13.0 | 4.0 | | |

*Summary of records of precipitation at stations in Alaska*—Continued.

8. FORT GIBBON.

[Latitude, 65° 12′; longitude, 152°.]

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 0.37 | 0.73 | 1.14 | 0.23 | 0.16 | 0.38 | 1.76 | ..... | 0.48 | 0.22 | 0.33 | Tr. | ..... |
| 1904 | .08 | .55 | .35 | .09 | .22 | .33 | 1.95 | 3.80 | .35 | .39 | .07 | 0.70 | 8.88 |
| 1905 | .37 | .47 | Tr. | ..... | .84 | 1.50 | 4.90 | 3.02 | ..... | ..... | 1.10 | .18 | ..... |
| 1906 | .65 | .20 | .30 | Tr. | 1.00 | ..... | ..... | ..... | ..... | [a].50 | .99 | .27 | ..... |
| | 6.0 | 2.0 | 3.0 | ..... | ..... | ..... | ..... | ..... | ..... | [a]5.0 | 9.9 | 2.7 | ..... |
| 1907 | 1.26 | ..... | .53 | ..... | .30 | ..... | 2.58 | 2.31 | 2.32 | 1.22 | .03 | ..... | ..... |
| | 12.6 | ..... | 5.0 | ..... | ..... | ..... | ..... | ..... | 4.0 | 12.0 | 1.5 | ..... | ..... |

[a] October 7 to 31.

9. FORT LISCUM.

[Latitude, 61° 27′ 30″; longitude, 146° 27′ 34″.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 10.42 | 13.60 | 4.72 | 3.87 | 2.23 | 3.24 | 4.29 | 6.44 | 8.62 | 6.62 | 5.62 | 9.61 | 79.28 |
| 1904 | 6.80 | .52 | .10 | 4.50 | .68 | 2.26 | 5.61 | 12.45 | 7.96 | 9.16 | 2.20 | 3.99 | 56.23 |
| 1905 | 3.63 | 5.73 | 7.17 | 2.96 | 7.02 | 3.83 | 3.49 | 9.85 | ..... | 6.06 | 10.37 | 7.75 | ..... |
| 1906 | 12.53 | 1.83 | 7.54 | 4.20 | 1.36 | 4.01 | 7.12 | 8.46 | 4.11 | 8.61 | 7.50 | 6.75 | 74.02 |
| | 97.6 | 13.5 | 103.2 | 31.6 | .5 | ..... | ..... | ..... | ..... | .5 | 57.5 | 63.5 | 367.9 |
| 1907 | 1.75 | 10.14 | 6.04 | .82 | 4.05 | 2.83 | 11.25 | 10.61 | 11.98 | 16.77 | 7.94 | 7.13 | 91.31 |
| | 17.5 | 95.0 | 63.0 | ..... | ..... | ..... | ..... | ..... | ..... | 10.4 | 38.1 | 51.95 | 276.0 |

10. FORT YUKON.

[Latitude, 66° 34′; longitude, 145° 18′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 0.62 | 1.09 | ..... | 0.34 | 0.35 | 0.77 | ..... | ..... | 1.70 | 1.30 | 0.26 | 0.38 | ..... |
| 1904 | .69 | .93 | 0.80 | 3.08 | 4.60 | 2.40 | 1.67 | ..... | ..... | ..... | ..... | ..... | ..... |

E. GRAND CENTRAL.

[Latitude, 64° 58′; longitude, 165° 14′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1907 | ..... | ..... | ..... | ..... | ..... | ..... | 3.61 | 7.19 | 5.06 | ..... | ..... | ..... | ..... |

11. HOLY CROSS MISSION.

[Latitude, 62° 16′; longitude, 159° 50′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | ..... | 0.78 | 1.26 | 0.39 | 0.22 | 1.52 | 1.97 | 3.22 | 2.47 | 0.11 | 0.90 | 1.02 | ..... |
| 1907 | 2.08 | .55 | 4.49 | ..... | ..... | 2.95 | 3.73 | 5.39 | 3.56 | .38 | .51 | ..... | ..... |
| | 15.5 | 3.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

12. JUNEAU.

[Latitude, 58° 19′; longitude, 134° 28′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 11.31 | 7.29 | 3.09 | 3.74 | 6.74 | 1.44 | 2.26 | 5.45 | 6.94 | ..... | ..... | ..... | ..... |
| 1904 | ..... | ..... | ..... | 7.84 | 6.50 | 10.40 | 8.15 | 4.04 | 9.20 | 9.34 | 8.36 | 8.89 | ..... |
| 1905 | 2.83 | 3.08 | 5.90 | 4.96 | 1.58 | 2.96 | 1.93 | 7.85 | ..... | 12.74 | 15.49 | 10.32 | ..... |
| 1906 | 4.35 | 1.57 | .56 | 3.03 | ..... | 1.34 | 3.58 | 3.21 | 3.68 | 12.30 | 12.27 | 2.17 | ..... |
| | ..... | ..... | Tr. | 2.0 | ..... | ..... | ..... | ..... | ..... | ..... | 7.0 | ..... | ..... |
| 1907 | .48 | 8.88 | 2.74 | 3.10 | 3.93 | ..... | 3.40 | 6.88 | 17.03 | 11.19 | 4.58 | ..... | ..... |
| | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 3.0 | 8.5 | ..... | ..... |

*Summary of records of precipitation at stations in Alaska*—Continued.

KATALLA.

[Latitude, 60° 11′; longitude, 144° 31′.]

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1907 | ..... | ..... | ..... | 7.70 | 4.85 | 8.29 | 14.95 | 11.41 | 12.34 | 25.62 | 12.44 | ..... | ..... |
| | ..... | ..... | ..... | 2.0 | ..... | ..... | ..... | ..... | ..... | 1.25 | 15.5 | ..... | ..... |

13. KENAI.

[Latitude, 60° 32′; longitude, 151° 19′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 0.83 | 2.18 | 0.44 | 0.67 | 0.54 | 1.16 | 2.48 | 3.78 | 2.72 | 0.77 | 0.78 | 0.18 | 16.53 |
| 1904 | .46 | .29 | .02 | .34 | Tr. | .87 | 2.44 | 3.50 | 4.01 | 1.71 | .48 | .66 | 14.78 |
| 1905 | .29 | .92 | .57 | .46 | .84 | .84 | 1.06 | 6.26 | .78 | 2.92 | 2.16 | 1.41 | 18.51 |
| 1906 | .30 | .10 | 1.24 | .17 | .29 | .57 | 4.41 | 2.95 | 1.41 | 1.74 | .39 | 1.16 | 14.73 |
| | 5.5 | 1.0 | 10.2 | 3.0 | ..... | ..... | ..... | ..... | ..... | Tr. | 7.8 | 10.0 | 37.5 |
| 1907 | .68 | .61 | .67 | .04 | 1.24 | 2.31 | 5.49 | ..... | 10.00 | 1.66 | ..... | ..... | ..... |
| | 5.0 | 15.5 | 8.8 | Tr. | ..... | ..... | ..... | ..... | ..... | 2.7 | ..... | ..... | ..... |

14. KECHUMSTUK.

[Latitude, 64° 07′; longitude, 142° 20′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904 | ..... | ..... | ..... | ..... | 1.80 | 0.83 | 2.23 | 0.94 | 0.64 | 0.30 | 0.03 | 0.23 | ..... |
| 1905 | 0.90 | 0.10 | 0.05 | 0.40 | .20 | 1.58 | .40 | 1.48 | 2.16 | 1.18 | .36 | .20 | 9.01 |
| 1906 | .36 | .05 | .06 | .27 | 1.69 | 1.61 | 3.25 | 2.51 | .51 | .31 | .29 | .20 | 11.11 |
| | 4.0 | .5 | 1.0 | 5.0 | ..... | ..... | ..... | ..... | ..... | 4.3 | .5 | 3.0 | 18.3 |
| 1907 | .12 | .20 | .27 | Tr. | 1.30 | 2.03 | 1.60 | 2.14 | .49 | .72 | .40 | ..... | ..... |
| | 2.0 | 3.0 | 4.0 | ..... | 12.0 | ..... | ..... | ..... | 2.0 | 9.0 | 4.0 | ..... | ..... |

15. KILLISNOO.

[Latitude, 57° 22′; longitude, 134° 29′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 4.05 | 2.4 | 0.20 | 6.15 | 2.55 | 0.75 | 1.15 | 2.30 | 3.10 | 12.45 | 3.65 | 5.00 | 43.75 |
| 1904 | 4.30 | 1.25 | 1.20 | 1.35 | 1.75 | 3.35 | 4.60 | 2.30 | 7.70 | 8.20 | 9.20 | 8.55 | 53.75 |
| 1905 | 1.90 | 2.80 | 2.60 | 2.20 | ..... | 1.20 | 1.60 | 4.30 | ..... | 4.10 | 8.40 | 7.75 | ..... |
| 1906 | 6.90 | 2.70 | .90 | 5.15 | 1.25 | 2.85 | 3.80 | 4.90 | 4.70 | 8.40 | 9.55 | 2.50 | 53.60 |
| | 31.0 | 1.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 4.0 | 10.0 | 46.5 |
| 1907 | 1.40 | 9.55 | 1.70 | 1.35 | 1.60 | 3.85 | 3.05 | 4.65 | 6.85 | 8.57 | ..... | ..... | ..... |
| | 14.0 | 31.5 | 7.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

16. LORING (FORKNAM HATCHERY.)

[Latitude, 55° 36′; longitude, 131° 37′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904 | ..... | ..... | 2.05 | 7.27 | 15.80 | 9.68 | 7.97 | 1.15 | 20.20 | 26.01 | 31.90 | 20.01 | ..... |
| 1905 | 5.18 | 13.19 | 16.53 | 11.65 | 9.46 | .84 | 5.26 | 12.71 | 14.07 | 17.94 | 28.49 | 25.92 | 161.24 |
| 1906 | 21.66 | 6.08 | 8.56 | 24.52 | 5.59 | 10.09 | 4.99 | 15.21 | 17.28 | 20.49 | 21.57 | 8.41 | 164.45 |
| | 19.5 | ..... | ..... | 4.2 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 7.5 | 31.2 |
| 1907 | .53 | 13.03 | 4.98 | 7.76 | 4.30 | 5.23 | 3.73 | 9.75 | 10.14 | 20.09 | 24.55 | ..... | ..... |
| | 15.0 | 19.2 | 24.2 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.0 | ..... | ..... |

17. MINE HARBOR.

[Latitude, 55° 45′; longitude, 160° 40′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 2.36 | 6.61 | 1.00 | 2.25 | 2.59 | 1.01 | ..... | 2.51 | 5.10 | 3.97 | 2.60 | 5.92 | ..... |
| 1904 | 3.00 | .49 | .29 | 1.42 | .81 | 1.30 | 3.79 | 4.78 | ..... | ..... | ..... | ..... | ..... |

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*Summary of records of precipitation at stations in Alaska*—Continued.

A. NOME.

[Latitude, 64° 30′; longitude, 165° 24′.]

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | | | | | | Tr. | 2.38 | 2.50 | 1.02 | 0.93 | 0.32 | 1.91 | |
| | | | | | | | | | | | | 20.8 | |
| 1907 | 2.64 | 1.46 | 3.37 | 0.10 | 1.12 | 1.31 | 2.08 | 2.68 | 1.41 | .16 | .06 | | |
| | 25.2 | 13.9 | 28.8 | | | | | | | | | | |

18. NORTH FORK.

[Latitude, 64° 30′; longitude, 142° 10′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905 | | | | | | | | 1.91 | 1.86 | | 0.50 | 0.20 | |
| 1906 | 0.70 | 0.50 | 0.10 | 0.80 | 1.98 | 2.74 | 2.69 | 1.01 | .72 | 0.42 | .55 | .38 | 12.59 |
| | 7.0 | 5.0 | 1.0 | 8.0 | | | | | | 3.2 | 4.5 | 4.5 | 33.2 |
| 1907 | .69 | .28 | .27 | Tr. | 1.34 | 1.92 | 1.57 | 3.19 | 2.00 | 1.40 | .20 | | |
| | 15.5 | 3.0 | 3.0 | | 4.0 | | | | 5.0 | 12.0 | 2.0 | | |

19. NUSHAGAK.

[Latitude, 58° 56′; longitude, 158° 24′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904 | | | | | | | 2.29 | 4.52 | 4.16 | 1.66 | Tr. | 0.56 | |
| 1905 | 0.20 | 1.45 | 0.40 | 0.40 | 2.51 | 2.75 | 3.84 | | | | | | |

C. OPHIR CREEK (CLAIM 15).

[Latitude, 64° 59′; longitude, 163° 39′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | | | | | | Tr. | 3.57 | 1.91 | | | | | |

20. ORCA.

[Latitude, 60° 35′; longitude, 145° 40′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 16.74 | 16.60 | | | | | | 10.75 | 16 67 | 17.70 | 13.24 | 23.44 | |
| 1904 | 11.69 | | 0.72 | 13.55 | | | | | 9.12 | 21.76 | 9.66 | 19.05 | |
| 1905 | 8.20 | 11.56 | 12.51 | 9.10 | 10.48 | 6.51 | 4.42 | 12.99 | | 15.57 | 29.64 | 12.81 | |
| 1906 | 10.63 | .94 | 5.34 | 7.54 | | | | | | | 17.08 | 8.56 | |
| | 76.0 | | 39 0 | 17.0 | | | | | | | 3.0 | 39.0 | |
| 1907 | 3.26 | 8.48 | 2.15 | | | | | | | 29.15 | 13.16 | | |
| | 3.0 | 100.0 | 25.0 | | | | | | | | 17.0 | | |

21. PETERSBURG.

[Latitude, 56° 49′; longitude, 132° 56′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904 | | | | | | | 9.20 | 2 33 | 15.33 | 12.89 | 13.89 | | |
| 1905 | | | | 7.17 | 3.03 | 1.95 | 4.46 | 10.76 | | | | | |

22. POINT BARROW.

[Latitude, 71° 17′; longitude, 156° 40′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 0.20 | 0.10 | | | | 0.10 | 0 74 | 1.43 | 0.09 | | | Tr. | 0.05 |
| 1904 | Tr. | .37 | 0.40 | 0.30 | | | | | | | | | |

K. POKER CREEK.

[Latitude, 65° 08′; longitude, 147° 28′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | | | | | | | | 1.40 | 3.70 | 1.70 | 0.25 | | |
| | | | | | | | | | | 24.0 | 3.30 | | |

*Summary of records of precipitation at stations in Alaska*—Continued.

23. RAMPART.

[Latitude, 65° 30′; longitude, 150° 15′.]

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905 | | | | | | 1.33 | 1.99 | 2.19 | 1.70 | 1.20 | 1.43 | 0.33 | |
| 1906 | 0.63 | 0.08 | 0.17 | 0.04 | 0.40 | .15 | 1.86 | 2.40 | .59 | .61 | .95 | .33 | 8.21 |
| | 7.2 | 2.0 | 1.8 | .5 | | | | | | | 10.2 | 3.5 | 25.2 |
| 1907 | 1.17 | .44 | 1.17 | .02 | .44 | 1.64 | 2.29 | 3.38 | 2.52 | .65 | .55 | | |
| | 12.0 | 4.5 | 12.8 | .25 | | | | | | | 6.3 | | |

B. SALMON LAKE.

[Latitude, 64° 54′; longitude, 164° 56′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | | | | | | Tr. | 4.92 | 3.33 | 3.26 | 0.81 | 1.56 | | |
| | | | | | | | | | | | 18.0 | | |
| 1907 | | | | | | 2.31 | 1.79 | 3.65 | 2.26 | | | | |

F. SHELTON.

[Latitude, 65° 13′; longitude, 164° 48′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1907 | | | | | | | 0.71 | 1.33 | 0.47 | | | | |

24. SITKA.

[Latitude 57° 03′; longitude 135° 19′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 6.61 | 8.68 | 2.57 | 4.25 | 3.65 | 0.90 | 2.85 | 3.90 | 5.80 | 14.52 | 6.50 | 14.97 | 75.20 |
| 1904 | 10.36 | .43 | 3.04 | 3.39 | 3.80 | 3.22 | 5.95 | 3.74 | 13.27 | 10.38 | 8.78 | 8.13 | 74.49 |
| 1905 | 3.82 | 4.78 | 4.21 | 7.52 | 2.44 | 2.25 | 2.83 | 7.38 | 8.80 | 7.03 | 11.37 | 11.21 | 73.64 |
| 1906 | 7.25 | 1.89 | 1.58 | 10.64 | 3.46 | 3.34 | 7.45 | 4.66 | 5.78 | 15.22 | 15.59 | 6.61 | 83.47 |
| | 8.3 | | 6.0 | | | | | | | | | 1.0 | 15.3 |
| 1907 | 2.36 | 3.55 | 1.75 | 2.16 | 3.84 | 3.66 | 4.66 | 12.60 | 15.75 | 11.77 | 12.13 | | |
| | 10.0 | 4.2 | 10.5 | | | | | | | | .70 | | |

25. SKAGWAY.

[Latitude, 59° 28′; longitude, 135° 20′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 2.08 | 1.44 | 0.43 | 0.48 | 1.10 | 0.56 | 0.02 | 2.08 | 1.41 | 9.99 | 1.60 | 3.35 | 24.54 |
| 1904 | 1.44 | Tr. | .33 | 2.31 | .84 | .97 | 1.07 | .18 | 2.80 | 5.35 | 6.28 | | |
| 1905 | | 1.14 | 1.14 | 1.27 | 1.11 | .10 | .16 | 2.14 | 2.67 | 2.17 | 3.25 | 2.21 | |
| 1906 | | 1.16 | .57 | 3.55 | .37 | 2.63 | 2.11 | 2.26 | 1.30 | 5.58 | 6.47 | .33 | |
| | | | Tr. | | | | | | | | | 3.0 | 3.0 |
| 1907 | .46 | 4.85 | .47 | 1.08 | .92 | | | 1.98 | 2.47 | 5.87 | 4.23 | | |
| | Tr. | Tr. | Tr. | | | | | | | | 10.0 | | |

26. SUMMIT.

[Latitude, 62° 55′; longitude, 143° 48′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | 1.19 | 0.46 | 1.04 | 1.26 | 1.02 | 4.25 | | [a] 0.03 | 0.12 | 0.07 | 0.74 | 0.49 | |
| | 11.0 | 5.0 | 12.0 | 13.0 | 5.0 | | | | | | 14.0 | 7.0 | |
| 1907 | 1.80 | .10 | .70 | .40 | .80 | 2.15 | | | | 1.40 | | | |
| | 18.0 | 2.0 | 7.0 | | 4.0 | | | | | 14.0 | | | |

[a] August 19 to 31.

G. SUMMIT ROADHOUSE.

[Latitude, 65° 02′; longitude, 147° 26′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1907 | | | | | | | 2.71 | 3.27 | | | | | |

*Summary of records of precipitation at stations in Alaska*—Continued.

27. SUNRISE.

[Latitude, 60° 54′; longitude, 149° 35′.]

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904 | 1.69 | 0.13 | 0.28 | 5.08 | 1.01 | 1.36 | 1.05 | 5.02 | 2.33 | 9.35 | 2.37 | 8.31 | 37.98 |
| 1905 | 2.12 | 1.93 | 1.64 | 3.41 | .84 | .69 | 1.40 | 4.46 | 1.86 | 4.36 | 9.47 | 8.48 | 40.66 |
| 1906 | 2.18 | .29 | 3.63 | 1.17 | 2.35 | 2.46 | 1.84 | 3.70 | 1.54 | 6.67 | 3.87 | 2.30 | 32.00 |
| | 30.7 | 3.7 | 33.9 | 3.8 | ..... | ..... | ..... | ..... | ..... | 5.0 | 15.0 | 25.5 | 117.6 |
| 1907 | 2.05 | 1.93 | ..... | 1.41 | 1.30 | .74 | 4.62 | 2.29 | 4.45 | 6.03 | 7.32 | 6.78 | ..... |
| | 7.5 | 29.0 | ..... | 2.0 | ..... | ..... | ..... | ..... | ..... | 14.2 | 31.4 | 19.7 | ..... |

28. TANANA CROSSING.

[Latitude, 63° 24′; longitude, 143° 24′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904 | ..... | ..... | ..... | ..... | 0.76 | ..... | 0.78 | 0.89 | 1.06 | 0.15 | 0.10 | 0.90 | ..... |
| 1905 | 0.24 | 0.08 | 0.18 | 0.00 | .14 | ..... | .37 | 2.95 | ..... | 1.40 | .60 | ..... | ..... |
| 1906 | .30 | .00 | Tr. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

G. TAYLOR.

[Latitude, 65° 42′; longitude, 164° 48′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1907 | ..... | ..... | ..... | ..... | ..... | ..... | 0.66 | 0.96 | 1.17 | ..... | ..... | ..... | ..... |

29. TEIKHELL.

[Latitude, 61° 23′; longitude, 145° 18′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904 | ..... | ..... | 0.05 | 0.75 | 0.40 | 0.79 | 1.53 | 2.00 | 1.21 | 2.82 | 0.90 | 2.95 | ..... |
| 1905 | 0.98 | 0.49 | 1.31 | .04 | Tr. | .80 | 1.05 | 1.02 | 1.41 | 1.48 | 4.90 | 2.34 | 15.82 |
| 1906 | 2.50 | .20 | 1.87 | .58 | .25 | 1.39 | 2.70 | .72 | .62 | 2.90 | 3.52 | .36 | 17.61 |
| | 25.0 | 2.0 | 26.2 | 5.5 | Tr. | ..... | ..... | ..... | 1.5 | 11.0 | 35.8 | 6.2 | 113.2 |
| 1907 | .37 | 1.81 | .56 | .07 | .80 | .68 | 8.20 | 2.00 | 1.20 | ..... | ..... | ..... | ..... |
| | 4.5 | 21.4 | 9.0 | Tr. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

30. TYONEK.

[Latitude, 61° 03′; longitude, 151° 10′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 1.95 | 3.91 | 0.45 | 1.01 | 0.69 | 1.59 | 2.62 | 5.69 | 2.76 | 1.15 | 0.64 | 0.53 | 22.99 |
| 1904 | 1.07 | .26 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 1905 | ..... | ..... | ..... | ..... | ..... | 1.27 | ..... | ..... | .92 | 3.19 | 3.10 | 1.24 | ..... |
| 1906 | .65 | .49 | 1.32 | .77 | .39 | 1.00 | 2.96 | 2.95 | 1.67 | ..... | 1.04 | 1.38 | ..... |
| | 16.0 | 7.0 | 26.0 | 20.0 | ..... | ..... | ..... | ..... | ..... | ..... | 12.5 | 14.0 | ..... |
| 1907 | 1.96 | ..... | 1.66 | .24 | ..... | 2.86 | 6.39 | 3.05 | 5.76 | 3.48 | ..... | ..... | ..... |
| | 21.0 | ..... | 33.0 | 2.0 | ..... | ..... | ..... | ..... | ..... | 4.7 | ..... | ..... | ..... |

31. UDAKTA (DUTCH HARBOR).

[Latitude, 53° 54′; Longitude, 166° 32′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905 | ..... | ..... | ..... | ..... | ..... | 4.69 | 1.73 | 3.39 | 3.46 | 5.00 | 13.78 | 8.28 | ..... |
| 1906 | 3.09 | 9.46 | 12.19 | 3.07 | 6.82 | 1.14 | 3.56 | 3.10 | 2.29 | 7.91 | 5.38 | 5.76 | 63.77 |
| | ..... | 4.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 4.0 |
| 1907 | 8.76 | 2.49 | 2.93 | 2.97 | 5.39 | 1.27 | 2.11 | 3.25 | ..... | 7.79 | ..... | ..... | ..... |
| | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.0 | ..... | ..... | ..... |

32. WOODY ISLAND (KODIAK ISLAND).

[Latitude, 57° 40′; longitude, 152° 25′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 4.74 | 8.10 | 0.39 | 4.61 | 4.92 | 7.80 | 4.38 | 4.79 | 7.95 | 6.27 | 3.30 | 8.29 | 65.54 |
| 1904 | 3.63 | ..... | Tr. | 3.68 | 3.35 | 2.26 | 1.36 | 4.89 | 4.63 | 4.84 | 5.20 | 3.24 | ..... |
| 1905 | 4.80 | 4.90 | 2.60 | 1.70 | 2.70 | 3.10 | 2.10 | ..... | 1.80 | 7.50 | 8.00 | 2.42 | ..... |
| 1906 | 2.50 | 8.60 | 3.50 | 3.80 | 5.10 | 4.70 | ..... | 1.50 | 6.70 | 5.10 | 3.20 | ..... | ..... |
| | 13.0 | ..... | 7.0 | ..... | ..... | ..... | ..... | ..... | ..... | Tr. | 3.5 | ..... | ..... |
| 1907 | 1.00 | 4.00 | Tr. | .61 | 6.30 | 5.20 | 3.50 | 3.70 | 9.00 | 8.70 | 7.70 | 6.5 | 56.21 |
| | 2.0 | 26.0 | Tr. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 4.5 | 5.5 | 38.0 |

*Summary of records of precipitation at stations in Alaska*—Continued.

33. DAWSON.[a]

[Latitude, 64° 05′; longitude, 139° 28′.]

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1901 | ..... | ..... | ..... | ..... | ..... | 0.94 | 1.32 | 1.64 | 1.17 | 2.25 | 1.10 | 1.55 | ..... |
| 1902 | 1.73 | 0.20 | ..... | 0.50 | 0.46 | .86 | 3.32 | 2.38 | 1.17 | .92 | 1.10 | .80 | ..... |
| 1903 | .50 | 1.35 | 0.60 | .60 | .39 | .50 | 1.11 | 1.47 | 2.41 | 1.25 | .45 | .65 | 13.01 |
| 1904 | .82 | .32 | .20 | .57 | .96 | 1.71 | 2.14 | 1.66 | 1.01 | .36 | .80 | 1.45 | 12.00 |
| 1905 | .23 | 1.30 | .40 | .94 | .97 | .25 | 1.93 | 2.51 | 3.52 | 1.84 | .24 | 1.24 | 15.37 |
| 1906 | 1.26 | .51 | .22 | .42 | 2.00 | .92 | 1.20 | 1.46 | 1.14 | .47 | 1.55 | .93 | 12.08 |
| 1907 | 1.53 | .34 | .88 | .23 | 1.06 | .85 | 1.93 | 1.28 | 2.34 | 4.09 | 2.60 | ..... | ..... |

34. WHITE HORSE.[a]

[Latitude, 60° 46′; longitude, 135°.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905 | 1.72 | 0.00 | 0.18 | 0.10 | 0.15 | 0.20 | 3.30 | 0.92 | 2.10 | 1.50 | 1.20 | 0.30 | 11.67 |
| 1906 | .55 | .75 | ..... | .20 | .07 | 1.78 | 3.33 | 1.39 | .50 | .30 | 1.10 | .20 | ..... |
| 1907 | .55 | .52 | 1.45 | .75 | .27 | 3.03 | 5.10 | 1.63 | .86 | .26 | .90 | ..... | ..... |

35. ATLIN.[a]

[Latitude, 59° 45′; longitude, 133° 46′.]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.06 | 0.48 | 1.55 | 0.76 | ..... |
| 1906 | 1.37 | 0.72 | Tr. | ..... | 0.25 | 1.74 | 1.62 | 0.71 | .78 | 1.45 | 2.55 | .88 | ..... |
| 1907 | .99 | 2.18 | .55 | 0.09 | .34 | .32 | .42 | 1.48 | .58 | .82 | .51 | ..... | ..... |

[a] These data were furnished by the Canadian Meteorological Service.

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# RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

All of these publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained, free of charge (except certain maps), on application.

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost.

4. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

## GENERAL.

The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper No. 45, 1906, 327 pp.

Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin No. 259, 1905, pp. 18–31.

The mining industry in 1905, by A. H. Brooks. In Bulletin No. 284, 1906, pp. 4–9.

The mining industry in 1906, by A. H. Brooks. In Bulletin No. 314, 1907, pp. 19–39.

Railway routes, by A. H. Brooks. In Bulletin No. 284, 1906, pp. 10–17.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1904: Bulletin No. 259, 1905, pp. 13–17.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1905: Bulletin No. 284, 1906, pp. 1–3.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1906: Bulletin No. 314, 1907, pp. 11–18.

Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin No. 259, 1905, pp. 128–139.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin No. 250, 1905, 64 pp.

Markets for Alaska coal, by G. C. Martin. In Bulletin No. 284, 1906, pp. 18–29.

The Alaska coal fields, by G. C. Martin. In Bulletin No. 314, 1907, pp. 40–46.

Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin No. 263, 1905, 362 pp. (Out of stock; can be purchased from Superintendent of Documents, Washington, D. C., for 35 cents.) Abstract in Bulletin No. 259, 1905, pp. 32–46.

Geographic dictionary of Alaska, by Marcus Baker, second edition by J. C. McCormick. Bulletin No. 299, 1906, 690 pp.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1907. Bulletin No. 345, pp. 5–17.

The distribution of mineral resources in Alaska, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1907. Bulletin No. 345, pp. 18–29.

The mining industry in 1907, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1907. Bulletin 345, pp. 30–53.

Prospecting and mining gold placers in Alaska, by J. P. Hutchins. In Bulletin No. 345, 1908, pp. 54–77.

Water-supply investigations in Alaska in 1906–7, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218, 1908, 156 pp.

### *Topographic maps.*

Alaska, topographic map of; scale, 1:2500000. Preliminary edition by R. U. Goode. Contained in Professional Paper No. 45. Not published separately.

Map of Alaska showing distribution of mineral resources; scale, 1:5000000; by A. H. Brooks. Contained in Bulletin 345 (in pocket).

Map of Alaska; scale, 1:5000000; by Alfred H. Brooks.

*In preparation.*

Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Second edition.

## SOUTHEASTERN ALASKA.

Preliminary report on the Ketchikan mining district, Alaska, with an introductory sketch of the geology of southeastern Alaska, by Alfred H. Brooks. Professional Paper No. 1, 1902, 120 pp.

The Porcupine placer district, Alaska, by C. W. Wright. Bulletin No. 236, 1904, 35 pp.

The Treadwell ore deposits, by A. C. Spencer. In Bulletin No. 259, 1905, pp. 69–87.

Economic developments in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin No. 259, 1905, pp. 47–68.

The Juneau gold belt, Alaska, by A. C. Spencer, pp. 1–137, and A reconnaissance of Admiralty Island, Alaska, by C. W. Wright, pp. 138–154. Bulletin No. 287, 1906, 161 pp.

Lode mining in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin No. 284, 1906, pp. 30–53.

Nonmetallic deposits of southeastern Alaska, by C. W. Wright. In Bulletin No. 284, 1906, pp. 54–60.

The Yakutat Bay region, by R. S. Tarr. In Bulletin No. 284, 1906, pp. 61–64.

Lode mining in southeastern Alaska, by C. W. Wright. In Bulletin No. 314, 1907, pp. 47–72.

Nonmetalliferous mineral resources of southeastern Alaska, by C. W. Wright. In Bulletin No. 314, 1907, pp. 73–81.

Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. In Bulletin No. 314, 1907, pp. 82–88.

Lode mining in southeastern Alaska in 1907, by C. W. Wright. In Bulletin No. 345, 1908, pp. 78–97.

The building stones and materials of southeastern Alaska, by C. W. Wright. In Bulletin No. 345, 1908, pp. 116–126.

Copper deposits on Kasaan Peninsula, Prince of Wales Island, by C. W. Wright and Sidney Paige. In Bulletin No. 345, 1908, pp. 98–115.

*Topographic maps.*

Juneau Special quadrangle; scale, 1:62500; by W. J. Peters. For sale at 5 cents each or $3 per hundred.

Topographic map of the Juneau gold belt, Alaska. Contained in Bulletin 287, Plate XXXVI, 1906. Not issued separately.

*In preparation.*

Physiography and glacial geology of the Yakutat Bay region, Alaska, by R. S. Tarr, with a chapter on the bed-rock geology by R. S. Tarr and B. S. Butler.

The Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright.

Berners Bay Special map; scale, 1:62500; by R. B. Oliver. (In press.)

Kasaan Peninsula Special map; scale, 1:62500; by D. C. Witherspoon and J. W. Bagley.

## CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

The mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall. Professional Paper No. 15, 1903, 71 pp. Contains general map of Prince William Sound and Copper River region; scale, 12 miles = 1 inch. (Out of stock; can be purchased from Superintendent of Documents for 30 cents.)

Bering River coal field, by G. C. Martin. In Bulletin No. 259, 1905, pp. 140–150.

Cape Yaktag placers, by G. C. Martin. In Bulletin No. 259, 1905, pp. 88–89.

Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin No. 259, 1905, pp. 128–139. Abstract from Bulletin No. 250.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin No. 250, 1905, 64 pp.

Geology of the central Copper River region, Alaska, by W. C. Mendenhall. Professional Paper No. 41, 1905, 133 pp.

Copper and other mineral resources of Prince William Sound, by U. S. Grant. In Bulletin No. 284, 1906, pp. 78–87.

Distribution and character of the Bering River coal, by G. C. Martin. In Bulletin No. 284, 1906, pp. 65–76.

Petroleum at Controller Bay, by G. C. Martin. In Bulletin No. 314, 1907, pp. 89–103.
Geology and mineral resources of Controller Bay region, by G. C. Martin. Bulletin No. 335, 1908, 141 pp.
Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin No. 345, 1908, pp. 176–178.
Mineral resources of the Kotsina and Chitina valleys, Copper River region, by F. H. Moffit and A. G. Maddren. In Bulletin No. 345, 1908, pp. 127–175.

*Topographic maps.*

Map of Mount Wrangell; scale, 12 miles = 1 inch. Contained in Professional Paper No. 15. Not issued separately.
Copper and upper Chistochina rivers; scale, 1:250000; by T. G. Gerdine. Contained in Professional Paper No. 41. Not issued separately.
Copper, Nabesna, and Chisana rivers, headwaters of; scale, 1:250000. D. C. Witherspoon. Contained in Professional Paper No. 41. Not issued separately.
Controller Bay region Special map; scale, 1:62500; by E. G. Hamilton. For sale at 35 cents a copy or $21.00 per hundred.
General map of Alaska coast region from Yakutat Bay to Prince William Sound; scale, 1:1200000; compiled by G. C. Martin. Contained in Bulletin No. 335.

*In preparation.*

The Kotsina-Chitina copper region, by F. H. Moffit.
Chitina quadrangle map; scale, 1:250000; by T. G. Gerdine and D. C. Witherspoon.

## COOK INLET AND SUSITNA REGION.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin No. 250, 1905, 64 pp.
Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin No. 259, 1905, pp. 151–171.
Gold placers of Turnagain Arm, Cook Inlet, by F. H. Moffit. In Bulletin No. 259, 1905, pp. 90–99.
Mineral resources of the Kenai Peninsula: Gold fields of the Turnagain Arm region, by F. H. Moffit, pp. 1–52; Coal fields of the Kachemak Bay region, by R. W. Stone, pp. 53–73. Bulletin No. 277, 1906, 80 pp.
Preliminary statement on the Matanuska coal field, by G. C. Martin. In Bulletin No. 284, 1906, pp. 88–100.
A reconnaissance of the Matanuska coal field, Alaska, in 1905, by G. C. Martin. Bulletin No. 289, 1906, 36 pp. (Out of stock; can be purchased of Superintendent of Documents for 25 cents.)
Reconnaissance in the Matanuska and Talkeetna basins, by S. Paige and A. Knopf. In Bulletin No. 314, 1907, pp. 104–125.
Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska, by S. Paige and A. Knopf. Bulletin No. 327, 1907, 71 pp.

*Topographic maps.*

Kenai Peninsula, northern portion; scale, 1:250000; by E. G. Hamilton. Contained in Bulletin No. 277. Not published separately.
Reconnaissance map of Matanuska and Talkeetna region; scale, 1:250000; by T. G. Gerdine and R. H. Sargent. Contained in Bulletin No. 327. Not published separately.
Mount McKinley region; scale, 1:625000; by D. L. Reaburn. Contained in Professional Paper No. 45. Not published separately.

## ALASKA PENINSULA AND ALEUTIAN ISLANDS.

Gold mine on Unalaska Island, by A. J. Collier. In Bulletin No. 259, 1905, pp. 102–103.
Gold deposits of the Shumagin Islands, by G. C. Martin. In Bulletin No. 259, 1905, pp. 100–101.
Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin No. 259, 1905, pp. 128–139. Abstract from Bulletin No. 250.
The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. In Bulletin No. 250, 1905, 64 pp.
Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin No. 259, 1905, pp. 151–171.
The Herendeen Bay coal field, by Sidney Paige. In Bulletin No. 284, 1906, pp. 101–108.

## YUKON BASIN.

The coal resources of the Yukon, Alaska, by A. J. Collier. Bulletin No. 218, 1903, 71 pp.

The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, by L. M. Prindle. Bulletin No. 251, 1905, 89 pp.

Yukon placer fields, by L. M. Prindle. In Bulletin No. 284, 1906, pp. 109–131.

Reconnaissance from Circle to Fort Hamlin, by R. W. Stone. In Bulletin No. 284, 1906, pp. 128–131.

The Yukon-Tanana region, Alaska; description of the Circle quadrangle, by L. M. Prindle. Bulletin No. 295, 1906, 27 pp.

The Bonnifield and Kantishna regions, by L. M. Prindle. In Bulletin No. 314, 1907, pp. 205–226.

The Circle Precinct, Alaska, by Alfred H. Brooks. In Bulletin No. 314, 1907, pp. 187–204.

The Yukon-Tanana region, Alaska; description of the Fairbanks and Rampart quadrangles, by L. M. Prindle, F. L. Hess, and C. C. Covert. Bulletin No. 337, 1908, 102 pp.

Occurrence of gold in the Yukon-Tanana region, by L. M. Prindle. In Bulletin No. 345, 1908, pp. 179–186.

The Fortymile gold placer district, by L. M. Prindle. In Bulletin No. 345, 1908, pp. 187–197.

Water supply of the Fairbanks district in 1907, by C. C. Covert. In Bulletin No. 345, 1908, pp. 198–205.

*Topographic maps.*

Fortymile quadrangle; scale, 1:250000; by E. C. Barnard. For sale at 5 cents a copy or $3 per hundred.

Yukon-Tanana region, reconnaissance map of; scale, 1:625000; by T. G. Gerdine. Contained in Bulletin No. 251, 1905. Not published separately.

Fairbanks and Birch Creek districts, reconnaissance maps of; scale, 1:250000; by T. G. Gerdine. Contained in Bulletin No. 251, 1905. Not issued separately.

Circle quadrangle, Yukon-Tanana region; scale, 1:250000; by D. C. Witherspoon. Contained in Bulletin No. 295. Not issued separately.

*In preparation.*

Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218, 1908, 156 pp.

Fairbanks quadrangle map; scale, 1:250000; by D. C. Witherspoon. Contained in Bulletin No. 337, 1908.

Rampart quadrangle map; scale, 1:250000; by D. C. Witherspoon. Contained in Bulletin No. 337, 1908.

Fairbanks Special map; scale, 1:62500; by T. G. Gerdine and R. H. Sargent.

## SEWARD PENINSULA.

A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska, in 1900, by A. H. Brooks, G. B. Richardson, and A. J. Collier. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900," 1901, 180 pp.

A reconnaissance in the Norton Bay region, Alaska, in 1900, by W. C. Mendenhall. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900."

A reconnaissance of the northwestern portion of Seward Peninsula, Alaska, by A. J. Collier. Professional Paper No. 2, 1902, 70 pp.

The tin deposits of the York region, Alaska, by A. J. Collier. Bulletin No. 229, 1904, 61 pp.

Recent developments of Alaskan tin deposits, by A. J. Collier. In Bulletin No. 259, 1905, pp. 120–127.

The Fairhaven gold placers of Seward Peninsula, by F. H. Moffit. Bulletin No. 247, 1905, 85 pp.

The York tin region, by F. L. Hess. In Bulletin No. 284, 1906, pp. 145–157.

Gold mining on Seward Peninsula, by F. H. Moffit. In Bulletin No. 284, 1906, pp. 132–141.

The Kougarok region, by A. H. Brooks. In Bulletin No. 314, 1907, pp. 164–181.

Water supply of Nome region, Seward Peninsula, Alaska, 1906, by J. C. Hoyt and F. F. Henshaw. Water-Supply Paper No. 196, 1907, 52 pp. (Out of stock; can be purchased of Superintendent of Documents for 15 cents.)
Water supply of the Nome region, Seward Peninsula, 1906, by J. C. Hoyt and F. F. Henshaw. In Bulletin No. 314, 1907, pp. 182–186.
The Nome region, by F. H. Moffit. In Bulletin No. 314, 1907, pp. 126–145.
Gold fields of the Solomon and Niukluk river basins, by P. S. Smith. In Bulletin No. 314, 1907, pp. 146–156.
Geology and mineral resources of Iron Creek, by P. S. Smith. In Bulletin No. 314, 1907, pp. 157–163.
The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks. Bulletin No. 328, 1908, 343 pp.
Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin No. 345, 1908, pp. 206–250.
The Seward Peninsula tin deposits, by Adolph Knopf. In Bulletin No. 345, 1908, pp. 251–267.
Mineral deposits of the Lost River and Brooks Mountain regions, Seward Peninsula, by Adolph Knopf. In Bulletin No. 345, 1908, pp. 268–271.
Water supply of the Nome and Kougarok regions, Seward Peninsula, in 1906–7, by F. F. Henshaw. In Bulletin No. 345, 1908, pp. 272–285.

*Topographic maps.*

The following maps are for sale at *5 cents a copy*, or $3 per hundred:
Casadepaga Quadrangle, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.
Grand Central Special, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.
Nome Special, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.
Solomon Quadrangle, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.

The following maps are for sale at *25 cents a copy*, or $15 per hundred:
Seward Peninsula, northeastern portion of, topographic reconnaissance of; scale, 1:250000; by T. G. Gerdine.
Seward Peninsula, northwestern portion of, topographic reconnaissance of; scale, 1:250000; by T. G. Gerdine.
Seward Peninsula, southern portion of, topographic reconnaissance of; scale, 1:250000; by T. G. Gerdine.

*In preparation.*

Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218, 1908, pp. 156.
Geology of the area represented on the Nome and Grand Central Special maps, by F. H. Moffit, F. L. Hess, and P. S. Smith.
Geology of the area represented on the Solomon and Casadepaga Special maps, by P. S. Smith.
The Seward Peninsula tin deposits, by A. Knopf.

## NORTHERN ALASKA.

A reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak rivers, by W. C. Mendenhall. Professional Paper No. 10, 1902, 68 pp.
A reconnaissance in northern Alaska across the Rocky Mountains, along the Koyukuk, John, Anaktuvuk, and Colville rivers, and the Arctic coast to Cape Lisburne, in 1901, by F. C. Schrader and W. J. Peters. Professional Paper No. 20, 1904, 139 pp. (Out of stock; can be purchased of Superintendent of Documents for 40 cents.)
Coal fields of the Cape Lisburne region, by A. J. Collier. In Bulletin No. 259, 1905, pp. 172–185.
Geology and coal resources of Cape Lisburne region, Alaska, by A. J. Collier. Bulletin No. 278, 1906, 54 pp.

*Topographic maps.*

Fort Yukon to Kotzebue Sound, reconnaissance map of; scale, 1:1200000; by D. L. Reaburn. Contained in Professional Paper No. 10. Not published separately.
Koyukuk River to mouth of Colville River, including John River; scale, 1:1200000; by W. J. Peters. Contained in Professional Paper No. 20. (Out of stock.) Not published separately.

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